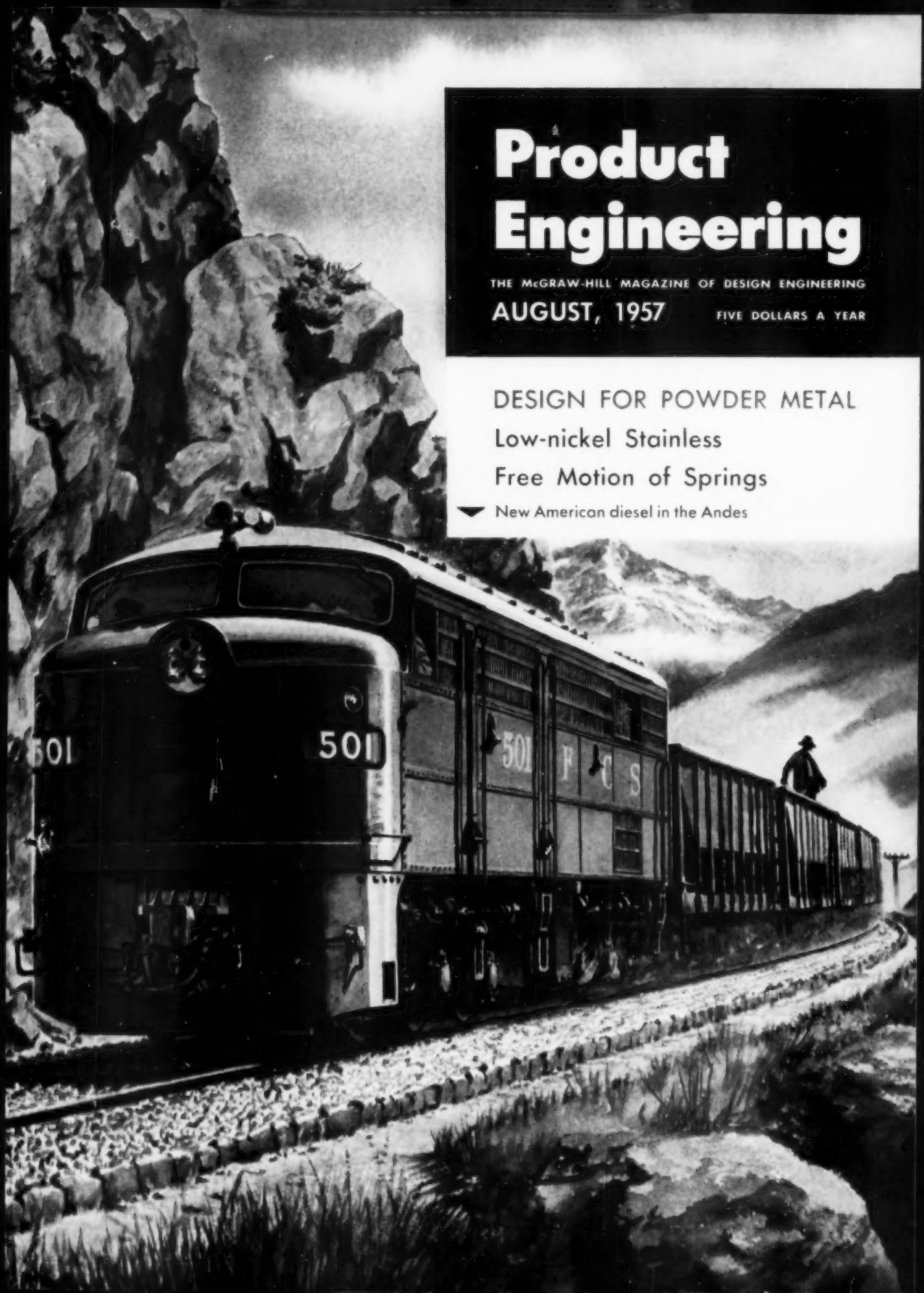

Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN ENGINEERING

AUGUST, 1957 FIVE DOLLARS A YEAR

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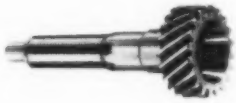

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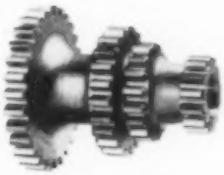
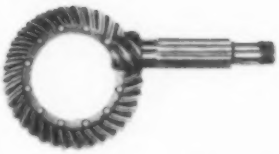
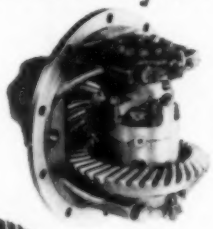
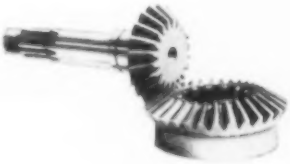
...to serve economically and

dependably on the job 

for which you buy them 

...and to do  credit to your product

and reputation 

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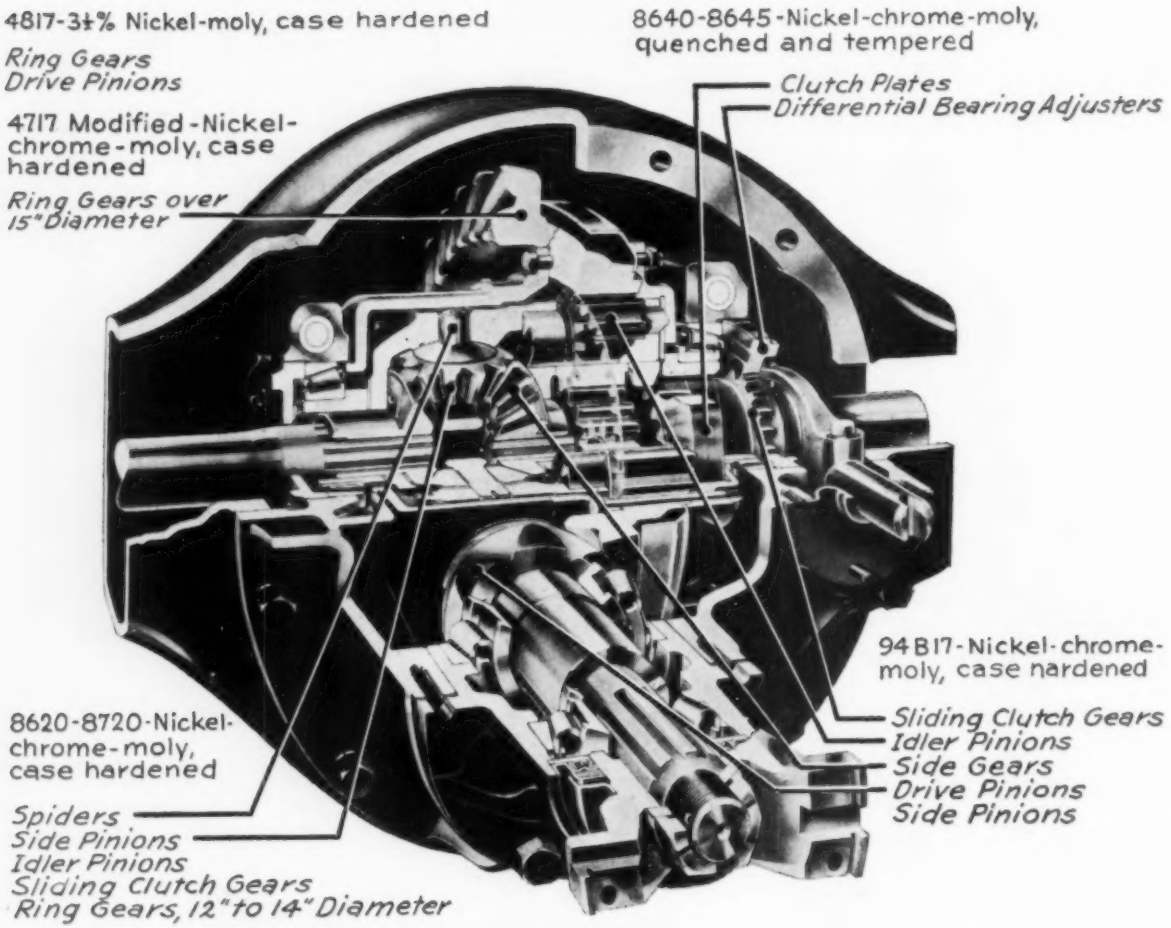

This axle assembly illustrates how one designer – Eaton Manufacturing Company, Cleveland – takes advantage of the versatility of Nickel Alloy Steels to improve the durability of heavy-duty mechanisms.

The 3½% nickel-moly steel provides drive pinions with stamina needed to cushion shock and take high tooth pressure.

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It's this high degree of selectivity found in Nickel Alloy Steels that makes it possible for designers at Eaton to choose just the right alloy steel for a part.

And, as you know, the *right* alloy steel in the *right* place pays off with maximum durability at lowest ultimate cost.

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Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN ENGINEERING

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Interesting to Note . . .

The Impossible Railroad

High above the Peruvian Andes, there is a sign which reads: TICLIO, ELEVATION 15,610 FEET. It's a passenger station on the Central Railroad of Peru—the highest in the world. In 1891, the 250-mile railroad was built over the mineral-rich Andes at a cost of $28 million. Moreover, 10,000 human lives were lost from disease, accident, or just plain exhaustion resulting from the rarified air at high altitudes. Strangely, the native Indians suffered most from this *soroche* or mountain sickness. Henry B. Meiggs, the builder of the road, had decamped from California after running up a debt of $800,000. As a master developer with outstanding vision, he realized the economic importance of building tracks across the Andes. Meiggs was brash and confident and convinced the Peruvian government with, "Anywhere a llama goes, I can take a train."

The engineering feat that followed was truly amazing. 58 bridges, 67 tunnels (one 4000 ft long), and 21 V-switches (or switchbacks to permit zigzagging up steep slopes) were built. At one point, one of the engineers told Meiggs: "It's impossible, sir! We just can't find enough footing for a track up there." Meiggs retorted, "Impossible be damned. That's where she's got to go. If you can't find a place to lay tracks, we'll have to just hang them from balloons."

Today there are six Alco DL-500 "World" locomotives in service, one is shown in our cover painting (lower left) crossing the highest divide at 16,600 ft. Note the precise, boulder-edged roadbed and the gaucho brakeman—he must ride in the open car because there is no caboose—it takes too much tractive power to drag one around. Howard Fogg made the painting. The "loco" will develop 65,000-lb starting effort at 30% adhesion, can travel 80 mph, weighs 211,500 lb, has a 1950-hp diesel.

Germany's Wartime Secret

Extrusion is as old as macroni, but until recent years worked on only the soft metals like lead and aluminum. Toothpaste tubes, tubing and such parts are so made—just by forcing the cold metal past a die with pressure. But steel! In the thirties, the Germans found the answer—a method of lubricating the steel so it would flow through the open die. Came the war, the Germans were able to use their discovery advantageously in the production of cartridge cases. The cold-extrusion process was so accurate, it could entirely eliminate the need for machining a part. This

(Continued on page 7)

ABP AUGUST, 1957 **Product Engineering** Vol. 28, No 8
A McGRAW-HILL PUBLICATION

PRODUCT ENGINEERING is published monthly with an additional Design Digest Issue in Mid-October, by McGraw-Hill Publishing Company, Inc., James H. McGraw (1860-1948), Founder. PUBLICATION OFFICE: McGraw-Hill Building, 330 W. 42nd St., New York 36, N. Y. See panel below for directions regarding subscriptions or change in address.

EXECUTIVE, EDITORIAL, CIRCULATION and ADVERTISING OFFICES: 330 W. 42nd St., New York 36, N. Y. Donald C. McGraw, President; L. Keith Goodrich, Vice President and Treasurer; John J. Cooke, Secretary; Nelson Bond, Executive Vice-President, Publications Division; Ralph B. Smith, Vice-President and Editorial Director; Joseph H. Allen, Vice-President and Director of Advertising Sales; A. R. Venezian, Vice-President and Circulation Coordinator.

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PRODUCT ENGINEERING articles are indexed in both the **Industrial Arts Index** and the **Engineering Index.** PRODUCT ENGINEERING publishes its own annual index including the Design Digest Issue in December issue each year. Copies are obtainable on request to the Editor.

SUBSCRIPTIONS. Send subscription correspondence and change of address to Subscription Manager, PRODUCT ENGINEERING, 330 W. 42nd St., New York 36, N. Y. Subscribers should notify Subscription Manager promptly of any change of address giving old as well as new address, and including postal zone number, if any. If possible, enclose an address label from a recent issue of the magazine. Please allow one month for change to become effective.

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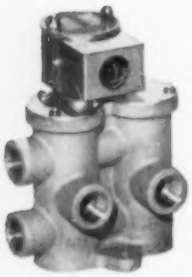

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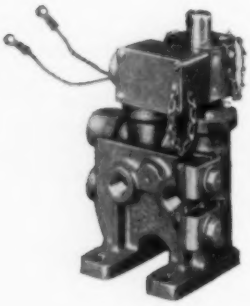

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because a generous power margin, short solenoid travel and pilot operation combine to prevent overheating and overloading. Note that these valves are accepted and used in automotive plants where assembly line production does not permit coil or valve failure.

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Main valve design is aimed at extremely long trouble free service. Resilient seats are tight sealing and are not affected or damaged by dirt or grit because they are of a self scavenging design. Witness their superior performance in such severe service as operating hopper doors on cement batching equipment and in other dusty environment.

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For complete data write for Catalog 6-C.

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LEAKPROOF (SHEAR-SEAL)

$75.00

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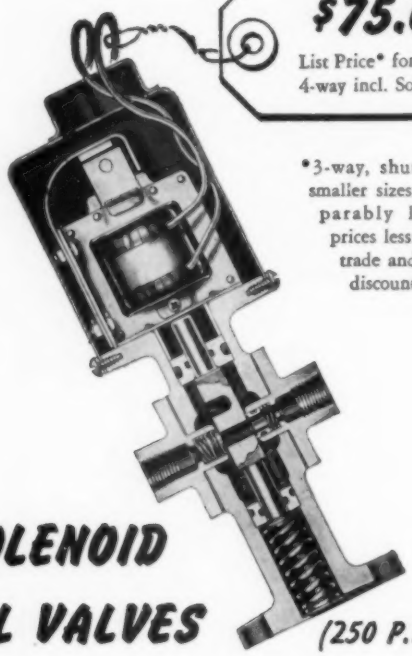

*3-way, shut-off and smaller sizes are comparably less. All prices less the usual trade and quantity discounts.

SOLENOID OIL VALVES (250 P.S.I.)

WHERE	WHY	HOW
Thread rolling machines	Holding position (leakproof)	Lapped sealing surfaces seal tight indefinitely as a result of wear compensation
Pressure testing in automotive production	Oil gets contaminated by scale in castings (not critical to dirt) reduced maintenance	Sealing surfaces in constant, intimate contact, dirt can't lock valving members—saves coil burn-out
Hydraulic work feed apparatus	(Leakproof) . . . as versus spool valves which cause overdemand on hydraulic system	Positive shut off of internal port to port leakage and of course, no external leakage
Machine tool chucking & clamping	Maintaining safe holding pressure (leakproof)	Saving auxiliary equipment such as pilot operated check valves
Automatic door openers	Quick action (high flow capacity)	No spools or poppets obstructing full, round flow passages
Solenoid controlled hydraulic system on machine you build	Better performance Lower manufacturing costs Reduce service problems	Shear-Seal valves have full flow, are leakproof, not sensitive to dirt Low priced, less auxiliary equipment and labor cost. Valves don't stick, saving coil burn-out; stay leakproof indefinitely, seals are wear compensating

BARKSDALE VALVES

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Ask for bulletin 5S-H

Interesting to Note . . . .

meant practically no wasted steel, the crux of Hitler's war machine.

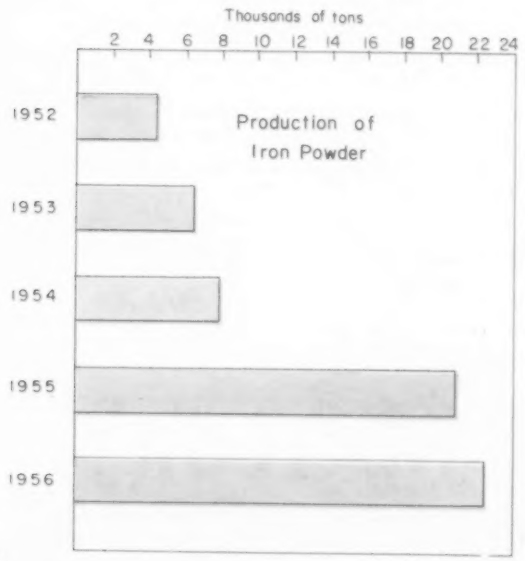
During the war, an American concern, the Heintz Mfg. Co., Philadelphia, Pa., obtained information from behind the enemy lines that this process existed. Upon the cessation of hostilities, contacts were renewed and through the aid of the Department of Commerce the company acquired, translated and evaluated German data. A company official was then sent to Germany. In the town of Lubeck, the official ran into a German from Texas who had been caught in Germany by the war. He became valuable in locating press operators, engineers, chemists and the actual presses which eventually were brought to the country to perfect the German techniques.

Heintz then used the process to produce a 75-mm shell. It was found that the techniques allowed a 90% reduction in scrap. Engineering parts, both with and without hollow sections, are now being produced successfully by this process in a number of places, for automobiles, aircraft and other uses. Design considerations in the cold extrusion of steels may be found on page 145.

A Lost Art Re-Born

History tells us that the majority of metallic elements were first produced as powders. The Egyptians familiarized themselves with powdered metals as early as 2000 B.C. They had no furnaces that could melt iron, so they powdered their iron ore, heated it as hot as they could, then shaped it. The iron powders bonded similarly as in today's sintering process. The Incas were known to have worked tiny nuggets of platinum in much the same fashion as sintered hard carbides are prepared today.

The ancient art of powder metallurgy became practically a lost one as a result of improved furnaces and the development of fusion metallurgy. The importance of metal powder was not again considered until William Wollaston, in 1829, perfected a method of producing malleable platinum. Unfortunately, it took another century before anything came of Wollaston's work. Slowly, the importance of powder metallurgy made its impression upon industry. In 1939 the powder-metal industry had a total business of something less than $2-million. Then the many applications of metal powders caught on—bearings, radio and telephone cores, magnets, cemented carbides.



The metal-powder industry has grown at a phenomenal rate over the past several years. Four years ago the domestic production *capacity* of the industry was 13.6 thousand tons/yr; in 1956 it expanded to 48.5 thousand tons/yr. The chart shows the actual tonnage of iron powder *produced* over the past five years. Basic consideration for the selection of materials and the design of parts by the powder-metallurgy process is the subject of a Special Report beginning on page 183.

The Flight That Failed

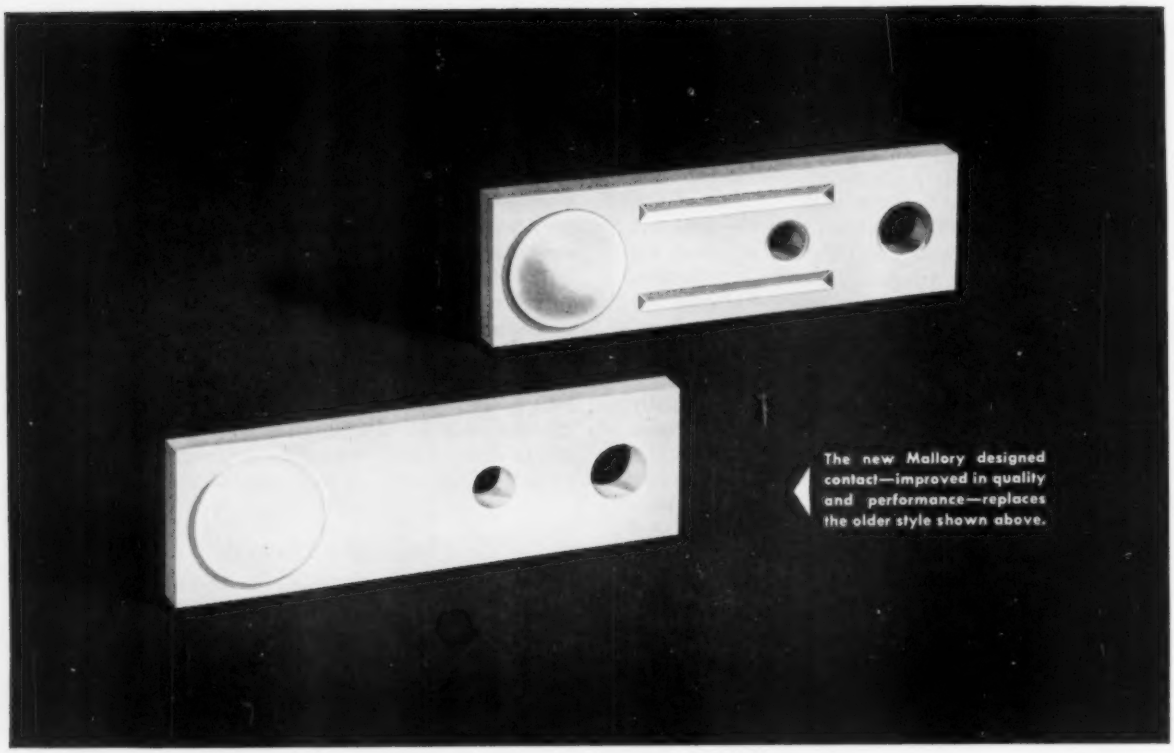
Assigned the routine task of checking out Army pilots in the operation of a C-47 (DC-3), Capt. W. J. Hull had an experience on May 2nd, 1943, which he will never forget. According to *Flying* (June 1944), Capt. Hull and a crew of two took off from Woodum Field, Roanoke, Va., in a plane converted to freight hauling. Their mission—familiarize the crew with the plane's flight characteristics. Parachutes were not worn. After climbing to the desired altitude, Capt. Hull turned the controls over to a crew member to practice a series of simple steep turns and stalls. Everything was normal.

At an altitude of 10,000 ft, with the plane in a descending left bank, the crewman showed difficulty in recovering from the nose-down attitude. Air speed was building up. The co-pilot realized the difficulty—600 lb of ballast that should have been in the rear baggage compartment was not there; the ship was too nose heavy. Both the pilot and co-pilot placed their feet on the dash panel and pulled back on the controls to no avail. Air speed was over 225 mph and the plane continued to accelerate.

Then, as they neared the mountains, the plane was suddenly hit by an updraft so violent all three in the plane momentarily lost consciousness. The high-speed jolt also caused a structural failure. Both wing tips had been broken off; both ailerons were blown away. The plane went into a violent spin with the crew practically helpless. The pilot tried every known way to recover. Finally, seconds from death, he rolled his rudder trim-tab control to a full-right position. Like a swooping eagle, the Douglas pulled out of the dive, blacking out the crew.

The next problem was to land the damaged craft. Since there was no way to determine the stalling speed, the plane had to be brought in at a high landing speed (120 mph). Miraculously, the plane crash-landed safely and the crew lived to tell their story. Of course, today there are devices to measure the angle of attack on aircraft. One such device, a recent development from England incorporating a mechanical computer, is described on page 148.

—Benedict A. Leerburger, Jr.



Production and Delivery Problems Solved by Mallory Contact Design Service

A major electrical equipment manufacturer required heavy duty contact assemblies made to rigid specifications. The original design called for hard drawn copper. To retain the hardness, contacts were brazed with a quick shot of heat—on a resistance welder. The silver solder frequently balled up, requiring hollow milling to remove surplus. Deliveries were often delayed—rejects ran high.

Mallory Contact Design Service proposed an alternate design. By switching to Mallory 3 metal, brazing was made easier. The use of Mallory 3 eliminated a hardening operation and enabled holes to be punched instead of drilled. Measured hardness at critical points is now guaranteed.

The customer benefited—almost no production problems, rejections were eliminated, delivery schedules could be met. Field life of the contacts within the finished equipment was greatly improved. Thanks to Mallory Contact Engineering Service, another customer got a better component, better service and a better product at no increase in cost.

FIVE MALLORY KEYS TO ECONOMY THROUGH CONTACT ENGINEERING

1. The most effective contact material from the extensive line developed by Mallory. More economical alloys often can satisfy *actual* service conditions.
2. The most economical contact design . . . for your purchasing, production and product needs.
3. The most economical backing material . . . from a group of Mallory alloys developed for this use.
4. The most economical backing member design in relation to contact and product design requirements.
5. The most economical method of assembling contact and backing member.

By coordinating *all* these important elements of contact design, Mallory can help you put into effect a long-range plan for cutting contact cost and assuring peak performance.

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To Watch

SMALL TRACES OF BORON . . . .

. . . . when added to austenitic chromium-nickel and chromium-manganese alloys will make the metal more ductile at high temperatures in a new process patented by Armco Steel Corp. The quantity of boron added to the alloy is extremely small ranging from 0.0001 to 0.0080%, and its effect on ductility is most marked within the 2000 to 2400 F temperature range. Armco expects the new process to increase the yield of usable mill products substantially. Some stainless steels, particularly the high alloy types, possess very low ductility at high temperatures and tend to crack or tear in hot rolling operations. The boron may be added in a variety of forms, including oxides as well as standard addition agents, and it appears to have no effect on the ingot structures, grain size or over-all nonmetallic content of the metal. But traces of boron appear to alter the basic fracture mechanism at high temperatures. The intergranular type of rupture is inhibited and failures are mainly transgranular. The quantity of boron added is gaged according to the grade and end use of the material.

PLASTIC AS A CONSTRUCTION MATERIAL . . . .

. . . . has come a step closer to reality with erection of the Monsanto inspired "House of the Future" at Disneyland. The house consists of four wings cantilevered from a central 16 foot square utility core. Each wing is made from two 8 x 16 ft modules with a top and bottom half called "bents." Bottom bent is molded from 10 layers of Owens-Corning fiberglas impregnated with polyester resin. The fiberglass layer, 0.3 in. thick, is topped with isocyanate foamed plastic 4 in. thick for the six feet of bent adjacent to the core and tapering off to 1½ in. at outer portions. The foamed plastic not only adds strength and rigidity but serves as a sound and thermal insulator. The wings rest on angles built up from layers of reinforced fiberglass, Douglas aircomb, and impregnated Kraft honeycomb. Top bents are similar to the bottom though somewhat thinner. Center core, also made of the same construction, rests on a concrete foundation. The plastic has high strength (tensile strength of 30,000 lb sq in.) but low section modulus. Designers have added stiffness by use of compound curves—the architects so-called shell principle. Deflection at the end of the cantilever under the most severe tests has measured ⅜ in. Tests have also indicated that the structure was tough enough to withstand the thermal expansion stresses. This eliminates the need for slip joints where the bents meet.

A DRY BATTERY WITH A PROBABLE LIFE EXPECTANCY OF TEN YEARS . . . .

. . . . has as its principle advantage a cell that can be recharged for years and still maintain a constant output. It has an indefinite shelf life. The battery has a chemical composition which is reversible and does not gas when charging; it maintains constant amperage and voltage over a temperature range from —65 to 165 F, and is resistant to shock and vibration. The cell has a capacity of 1½ amp-hrs. The battery, which was developed at the Naval Ordnance Lab., White Oak, Silver Spring, Md., is about the size of a man's wrist watch, and is composed of an anode made of lead lead-oxide and a cathode of consolidated silver powder. The electrolyte, potassium hydroxide, is retained in 5 thin dynel absorber pads and is

(*Continued on page 10*)

separated from the cathode by a Synpor barrier. The battery is enclosed in a metal case, sealed with a special resin, and encased in plastic. The battery delivers 0.9 volts compared with 1½ volts for the conventional dry cell. Suggested applications are in transistor circuits for hearing aids, walkie-talkie receiver-transmitters, air navigation systems and portable radios. Mass production costs are likely to run about 50% higher than for a mercury battery.

WELDED STEEL HIGH PRESSURE CAPSULES . . . .

. . . . which operate at 100 to 200 psi is the result of a welding technique which localizes the welding heat at the seams, meaning that special high alloy steel diaphragms can be fabricated in the fully heat treated condition. The new steel capsules are reported to offer a higher degree of sensitivity than copper alloy capsules, and will not require the use of bi-metal temperature compensators. Development of the welding technique is by Kelvin and Hughes Ltd., Barkingside, London. A big advantage is the use of materials having low temperature-expansion and low temperature–Youngs Modulus coefficients (Ni-Span 'C') eliminating the bi-metal compensators. Stainless and spring steels, and the Nimonics are also used. Other advantages are: exposure to higher temperatures than were possible with soft soldered or brazed joints; lower hysterisis, and higher differential pressures. Details of the welding technique have not been disclosed.

THIS YEAR'S GRADUATING ENGINEERS . . . .

. . . . are starting work at salaries averaging $465 a month, according to figures based on Lehigh University's graduating class. This average starting salary is up 11% from last year. This figure also is the average starting salary for mechanical engineers. Electrical engineers commanded the top starting salary this year with an average of $488. Engineering physicists were second with $481. E. A. Teal, director of placement and counseling services at Lehigh, expects that starting salaries will be increased about 5% to $485 for next year's graduates, but that the demand may not be as heavy next year as this. Statistics show that there were 5663 interviews held in the past seven months, and from these there were 415 acceptances of positions with 199 companies. The type of work was rated as the top factor influencing job selection, with location of employment and reputation of the company next in that order.

THE SMALLEST GAS TURBINE AIRCRAFT ENGINE . . . .

. . . . ever built, to power a one-man helicopter, is being designed by the Solar Aircraft Co. under a contract by the Naval Bureau of Aeronautics and the U.S. Army. The engine is 20 in. high, 15½ in. in dia, weighs 50 lb, and will produce 55 shaft horsepower plus 12 lb of jet thrust on a 100 F day. Operating on standard fuels, the rotor of the engine will spin at 57,600 rpm.

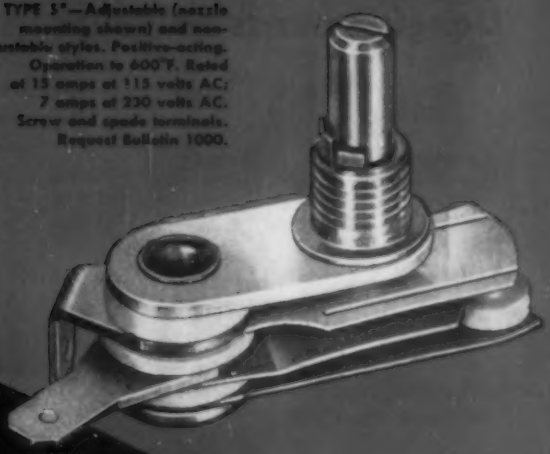
MAGNESIUM WILL REPLACE ALUMINUM . . . .

. . . . in the manufacture of motor die cast end shields for fractional horsepower motors at Westinghouse Electric Corp.'s Lima, Ohio, plant. While making possible a substantial cost reduction, magnesium's mechanical, thermal fire, and corrosion tests results proved satisfactory for this application. The mechanical properties of the magnesium die cast alloy, such as tensile and shear strengths, are about 15-25% less than those of the aluminum die cast alloy. Minor design changes in the end shields compensate for this. Tests also showed that the use of magnesium

(*Continued on page 12*)

TYPE H†—Positive acting, adjustable, for fry pans, skillets, and other appliances. Fail-safe, open in low to 500°F in high. Rated at 1650 watts at 115 volts AC. See Bulletin 10,000.

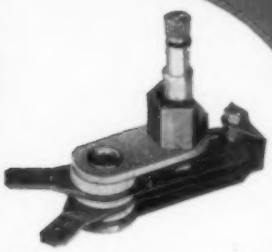
TYPE S*—Adjustable (nozzle mounting shown) and non-adjustable styles. Positive-acting. Operation to 600°F. Rated at 15 amps at 115 volts A.C; 7 amps at 230 volts AC. Screw and spade terminals. Request Bulletin 1000.



®

STEMCO THERMOSTATS

give you more of what you want most



TYPE SA*—Adjustable (shown) and non-adjustable. Snap acting with electrically independent bimetal. Also single-pole, double-throw. Non-inductive-load rating 15 amps at 115 volts AC; 10 amps at 230 volts AC. Spade or screw terminals. Request Bulletin 2000.

TYPE A*—Semi-enclosed. Insulated, electrically independent bimetal disc gives fast response and quick, snap-action control. Operation from –10° to 400°F, or higher on special order. Various mountings and terminals. Rated at 6½ amps at 115 volts AC, 4 amps at 230 volts AC and 28 volts DC. See Bulletin 3000.

Features such as snap or positive-action . . . various terminal arrangements or mounting provisions . . . different temperature ranges—there's a *standard* type Stemco thermostat for your *special* needs. That means you cut down on lead time, research and development costs, tooling and production inventory. Specify Stemco and you get *better thermostats, faster and for less* than you can make them or buy them elsewhere.

TYPE D*—For laundry dryers or other surface and warm air applications. Snap-acting disc type U.L. approved for operation to 300°F. Rated at 25 amps at 120-240 volts A.C. Open or enclosed styles. Request Bulletin 8000.

Size and weight are particularly important in appliance and apparatus applications. And here Stemco thermostats score, too. Their compactness and lightness give a better product without sacrificing performance.

Economy of mass production of many standard Stemco types with literally hundreds of terminal arrangements and mounting provisions means your product costs less to make, is easier to sell.

Availability of most types is good. Design is flexible for your special applications, tooling is in existence for short-term delivery. If heat control is your problem, Stemco thermostats can provide the answer.

AA-8761

*Refer to Guide 400 EO for U. L. and C.S.A. approved ratings.

†Patent Applied For

STEMCO® THERMOSTATS

STEVENS manufacturing company, inc.

Lexington and Mansfield, Ohio

for this application did not introduce an additional fire hazard. Weight reduction also will result in lower shipping and handling costs. The use of magnesium is part of Westinghouse's program in the application of this metal. Other applications include radar antenna, test equipment, teleprinters, walkie talkies, electronic rectifiers, automotive housings and others.

THE TRANSISTOR HAS A COMPETITOR . . . .

. . . . with the development of the "solion" (from "ions in solution") at the Naval Ordnance Lab., White Oak, Silver Spring, Md. The device operates with the flow of ions between electrodes in an iodine solution, instead of a solid, like a transistor, or in a vacuum in a tube. According to NOL, its most important application will be in inertial guidance systems. The solion is sensitive to changes in outside conditions, and the flow of ions can be stimulated and varied by changes in temperature, pressure, acceleration, sound, and light. Besides making possible simpler electronic control systems, they will be cheaper and smaller, with a solion unit weighing several ounces replacing a control system weighing several hundred pounds. Other applications might be: furnace temperature and pressure regulators, heat controls and fire alarms, and hydraulic control systems.

METAL STRIP AND TUBING DIRECTLY FROM POWDER . . . .

. . . . in a complete production line is now in the pilot model stage at E. W. Bliss Company's Rolling Mill Div., in Salem, Ohio. Other products as well can be fabricated. Savings are about 80% over conventional rolling costs, and the process can be applied to copper, nickel, titanium and other metals. Metal powder feeds through a hopper to the compacting rolls, then through a sintering furnace and the hot mill rolls. The finished strip is said to compare favorably with fine strip rolled by conventional multi-cycle rolling techniques.

AND IN ADDITION . . . .

. . . . Power-assisted optional equipment on cars is more and more in demand, according to reports from Dodge Div. of Chrysler. Through the first 5 months of 1957 the demand for power steering is up to 46% from 25% last year; power brakes are up to 26% from 19.7% last year; and automatic push-button transmissions are asked for on 96.1% of all Dodges compared to 90% in 1956. Factory installed air conditioners are up to 2.8% from 0.4% last year. . . . Price reductions up to 44% on adhesives for Mylar polyester film have been announced by the DuPont Company's industrial finishes division. . . . General Motors says that the automotive gas turbine is ready to compete with piston engines for heavy duty and military vehicles. With normal rating of 50,000 gross combined weight, the Turbo-Titan has an acceleration (0 to 40 mph) improvement of 27.5% over a standard piston truck engine and a 17% gradeability improvement. Miles-per-gallon is better for the piston engines, but the turbine engine will take a greater payload. . . . Something new in simulators, a tank fighting compartment simulator has been developed for the Army by the Lehigh Engineering Associates, Newark 2, N. J. The simulator is not a training instrument, but will help to design tanks by reproducing the various forces which act upon a tank fighting compartment and on the gunner in it. . . . The first completely automatic seamless steel tube mill, the Mannesmann Tube Co., Ltd., Sault Ste. Marie, Ontario, Canada, recently went into production. Seamless pipe from 4½ in. OD to 10¾ in. OD will be produced. Its annual rated capacity is 225,000 tons of oil field API approved pipe.

La Salle fatigue-proof™ STEEL BARS

MADE BY e.t.d. PROCESS
Elevated Temperature Drawing

HAVE A UNIQUE COMBINATION OF

uniform properties

HIGH STRENGTH, MACHINABILITY, RESISTANCE TO WEAR AND FATIGUE, DIMENSIONAL STABILITY

1⅜" round FATIGUE-PROOF. Magnification: 750X

The microscope shows the uniformity of FATIGUE-PROOF. Its uniformly pearlitic structure parallels its uniformity of properties from the surface to the center of the bar.

FATIGUE-PROOF strength and hardness are developed by "e.t.d." (Elevated Temperature Drawing). Unlike quenching and tempering, its effect is the same from surface to the center of the bar. It works a large bar as uniformly as it does a small bar.

There is no mass effect.

The microscope proves it. Surface, center, or mid-radius, FATIGUE-PROOF is pearlitic. There are no mixtures of bainite, martensite, and pearlite. FATIGUE-PROOF is uniform bar to bar, size to size, and lot to lot.

T. M.—Trade-marks of La Salle Steel Company

JUST PUBLISHED—Request your copy of 24-page brochure, "A new material" . . . it tells the complete story of FATIGUE-PROOF.

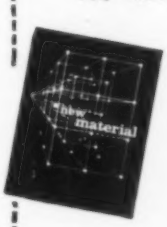
Name_____

Company_____

Address_____

City_____ Zone____ State_____

Mail to La Salle Steel Co., 1430 150th St., Hammond, Ind.



La Salle STEEL CO.

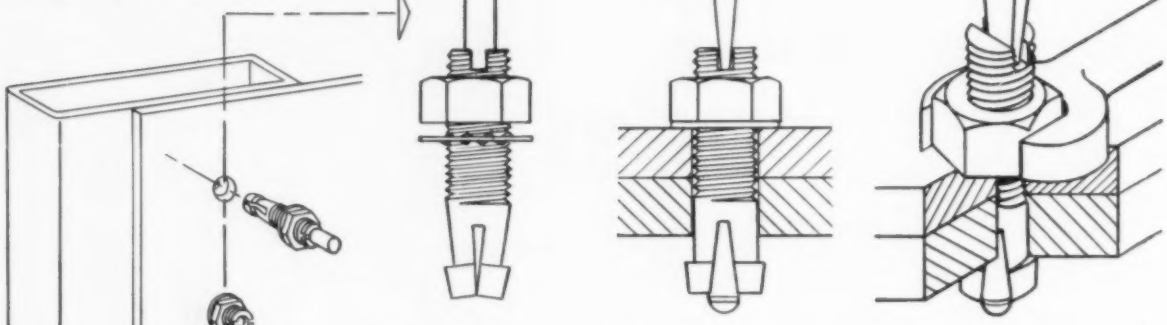
1430 150th Street • Hammond, Indiana

Manufacturers of America's Most Complete Line of Quality Cold-Finished Steels Bars

Simplified Bolting and Riveting in Blind Applications

For fastener applications accessible only from one side of the work, you can now bolt or rivet without special tools . . .

Blind Bolt . . .

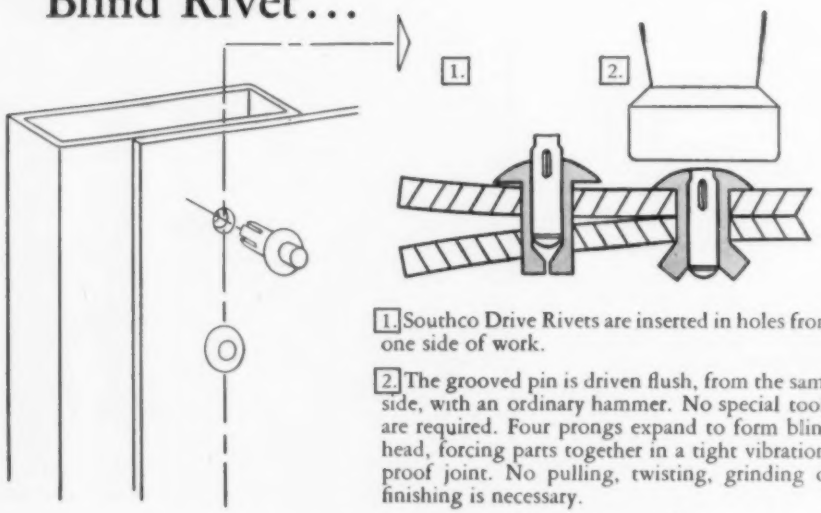


1. This is the Southco "Drivebolt" Fastener. A nut is threaded on and the bolt is inserted from one side of the work.

2. The pin is driven flush, expanding a head on blind side of hole. Pin is then further depressed with screwdriver blade to clear slot.

3. Working from open side, bolt is kept from turning by screwdriver, nut is tightened with wrench. Result—bolted strength achieved from one side of job.

Blind Rivet . . .



1. Southco Drive Rivets are inserted in holes from one side of work.

2. The grooved pin is driven flush, from the same side, with an ordinary hammer. No special tools are required. Four prongs expand to form blind head, forcing parts together in a tight vibration-proof joint. No pulling, twisting, grinding or finishing is necessary.

FREE!

Fastener Handbook

Send for your free copy of Fastener Handbook No. 7, just released. Gives complete engineering data on these and many other special fasteners. Fifty-two pages, in two colors.

Write on your letterhead to Southco Division, South Chester Corporation, 236 Industrial Highway, Lester, Pa.

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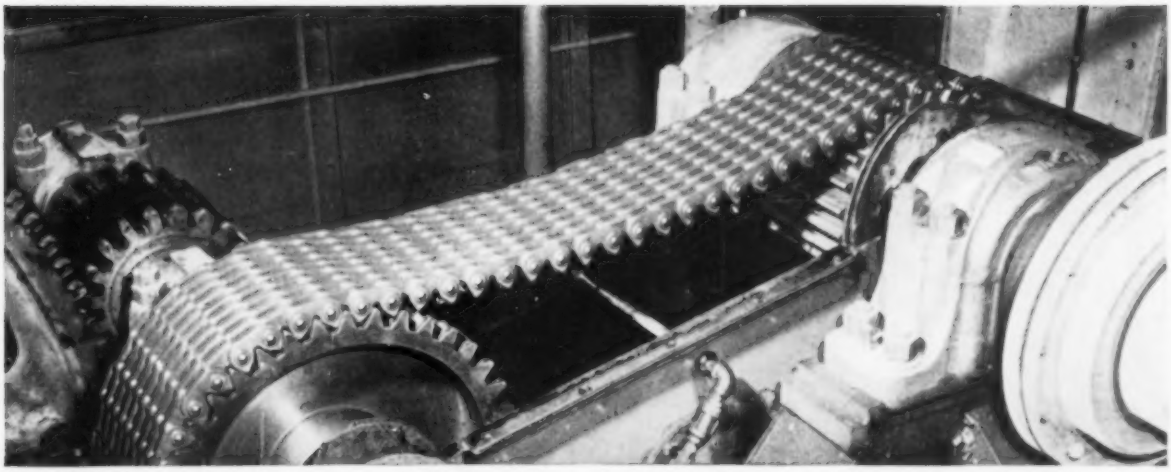
SOUTHCO FASTENERS

LION



HIGH SPEED. Traveling at speeds as high as 5000 fpm, silent chain drives readily accommodate the extreme peak loads without losing their better-than-98% efficiency.

How LINK-BELT silent chain drives survive industry's roughest requirements

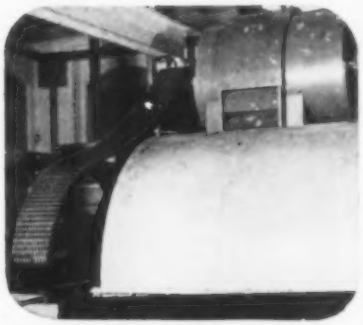
Would your drives do as well?

On applications like these and scores more, no other type of drive is the equal of Link-Belt silent chain. Ask your nearby Link-Belt office for a copy of comprehensive 88-page Data Book No. 2425.

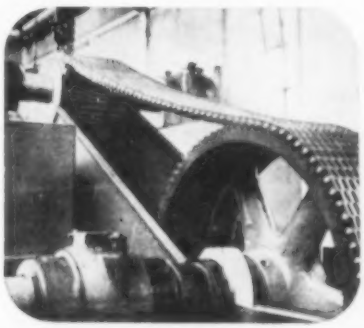
LINK-BELT

SILVERSTREAK SILENT CHAIN DRIVES

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,678-A

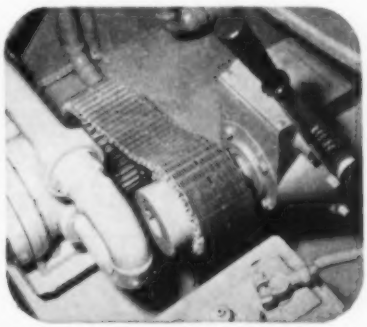


LARGE OR SMALL HP. On a 300 hp drive like this or at fractional hp, silent chain is always lower in ultimate cost.

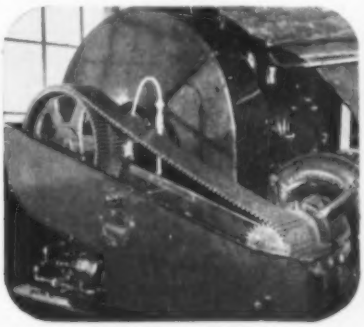


LARGE RATIOS. Link-Belt silent chain operates efficiently on extremely short centers at ratios as high as 10-to-1.

ADVERSE OPERATING CONDITIONS. Heat, humidity and cold have little effect on Link-Belt silent chain drive performance.



LIMITED SPACE. Easy to assemble in close quarters, Link-Belt silent chain permits built-in drives, compact housings.



LONG LIFE. This drive is 16 years old and still going strong. Not unusual—many others have lasted twice that long.

Naugatuck KRALASTIC

non-corrosive KRALASTIC curb and cathodic terminal boxes

A unique rubber-resin blend, Naugatuck's Kralastic® is now used in extension-type Curb Boxes and in Cathodic Terminal Boxes*. Why in Curb Boxes? Because Kralastic can't corrode; it permits the telescoping section to collapse when necessary. Why in Cathodic Terminal Boxes? Because Kralastic permitted design changes for more simplified testing. In both instances, the non-corrosive character of Kralastic eliminates the nuisance of hard-to-remove caps.

Kralastic offers superior physical properties that no other material can match. It can't rust or rot. It is lightweight, about 1/7th the weight of iron. It is free from electrolytic action and impervious to water and soil elements.

Kralastic has proven its superiority for use in pipe, fittings, conduits, etc.—in fact, wherever severe corrosive conditions limit the life expectancy of metals.

For more information about this tough and durable plastic material, why not write to us on your company letterhead.

*Kralastic Extension Type Curb Boxes and Cathodic Terminal Boxes are fabricated by HANDLEY-BROWN HEATER CO., Jackson, Michigan.

United States Rubber

Naugatuck Chemical Division

Naugatuck, Connecticut

BRANCHES: Akron • Boston • Gastonia, N.C. • Chicago • Los Angeles • Memphis • New York • Phila.
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You Can Count On... to Pay Off!

It's the **Original Equipment* idea . . . which simply means that, when you're figuring on electrical or mechanical counters in any new product, it pays to *design them in, when you begin.*

For then Veeder-Root quite likely can save you time and money by adapting or modifying a *standard* counter to your needs, instead of a special which you might specify on your own. This solves the counter problem . . . and saves you time in engineering, purchasing and assembly.

What's more, you give your product new sales-advantages: Direct-reading digits, instead of hard-to-read dials and verniers . . . instant remote indication if needed . . . up-to-the-minute performance records that serve as a basis for production-*Count*rol, and as proof of your performance guarantee. So don't let counters take a back seat in your new-product plans. *Design them in, when you begin* . . . it pays in many ways. Do you have the newest Veeder-Root Catalog? Write

Series 1205
Reset Magnetic Counter

Everyone Can Count on Veeder-Root

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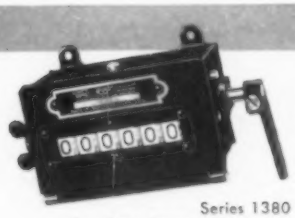
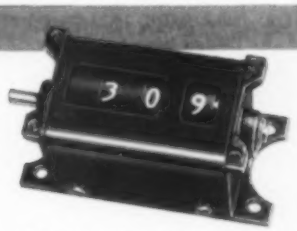
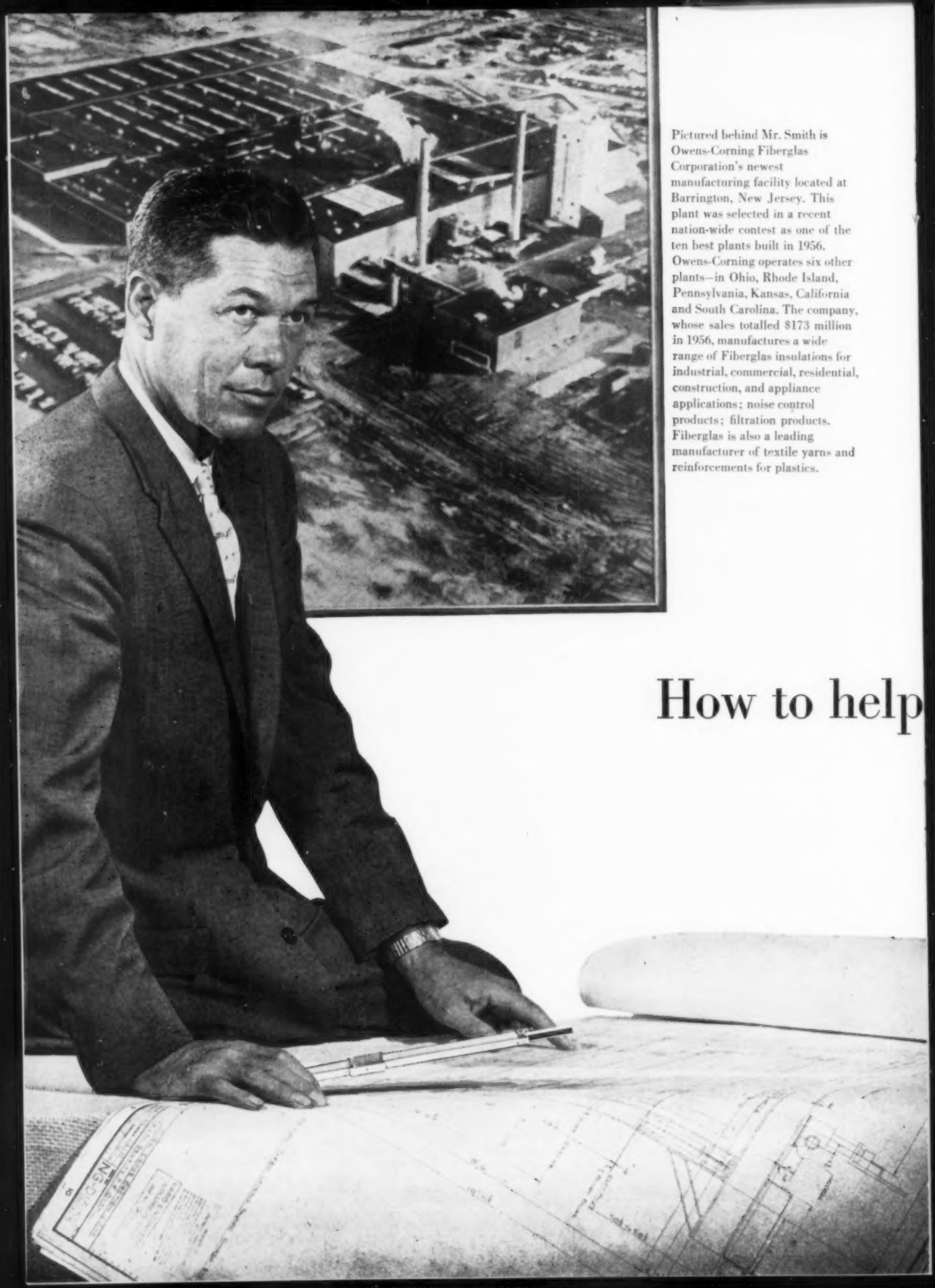


Series 1380
Box-Type Counter (Ratchet, Revolution, or Geared)

4-bank Counter for Radio Transmission Equipment



360-degree Bearing Counter



Pictured behind Mr. Smith is Owens-Corning Fiberglas Corporation's newest manufacturing facility located at Barrington, New Jersey. This plant was selected in a recent nation-wide contest as one of the ten best plants built in 1956. Owens-Corning operates six other plants—in Ohio, Rhode Island, Pennsylvania, Kansas, California and South Carolina. The company, whose sales totalled $173 million in 1956, manufactures a wide range of Fiberglas insulations for industrial, commercial, residential, construction, and appliance applications; noise control products; filtration products. Fiberglas is also a leading manufacturer of textile yarns and reinforcements for plastics.

How to help

"Manufacturers' catalogs are such important information sources for engineers that we cannot help but be concerned with the problem of how we can have adequate and constantly available files of them.

"In my opinion, the most satisfactory solution to this problem lies in the Sweet's plan of filing manufacturers' catalogs, before they are distributed to engineering offices, in classified, indexed, and bound collections.

"The Catalog Files which Sweet's distributes each year are tremendously helpful, and the catalogs these Files contain are in steady use here. The subject of how catalogs can be made most conveniently and consistently useful in engineering offices is a subject worth careful study by every manufacturer. Our marketing management has made such a study in respect to our catalogs, and six different Owens-Corning Fiberglas catalogs were pre-filed this year in one or more Sweet's Files, where they provide immediate information about our products whenever it is wanted."

Harry V. Smith, *Chief Engineer*
Owens-Corning Fiberglas Corporation
Toledo, Ohio

engineers speed product selection

Yes, Mr. Smith, product information is vital to engineers. That's why time and again they vote their Sweet's Files their most valuable sources of product comparison and specifying information... and tell us that the continued growth of these Files is the surest answer to their catalog problems.

Next year, more Sweet's Files than ever before will be made available to industry's engineers. In these 1958 Files, hundreds of leading manufacturers will make selection and specifying information immediately and constantly available to you... all of it permanently bound, classified by product types for easy comparison, completely indexed for rapid use.

There is no better, time-saving habit than to look first in your Sweet's File to compare competing products and specify a needed one.

SWEET'S CATALOG SERVICE
Division—F. W. Dodge Corporation
119 West 40th Street, New York 18.

Designers, producers and distributors of manufacturers' market-specialized catalogs for the industrial and construction markets.
Over 53,000,000 catalog copies distributed for 1,740 companies in 1957.

ANNOU

Increased capacity ratings

THE Timken Roller Bearing Company announces an increase in the capacity ratings of most series of Timken® tapered roller bearings. Increases range up to 39%. Most are in the neighborhood of 10%. Some are negligible.

Permits Use of Smaller Bearings

This increase in capacity ratings makes it possible for many of you to use smaller bearings. Your products can be made more compact. You can save weight. You may be able to reduce the size of your shafts and housings. And you may be able to use Timken bearings in new applications where they have not been practicable in the past.

3 Reasons for Increases

What led to these increases in Timken bearing capacities? Three things: First, a careful review of more than 6,000 different laboratory studies

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

NCING!

for Timken® bearings

of Timken bearing performance on fatigue life machines. From these exhaustive studies, conducted on an organized, scientific basis since 1924, we keep learning more and more about predicting bearing life.

Second, refinement in the method of analyzing these studies mathematically.

Third, a careful review of the life of millions of Timken bearings in the field.

How Much Can This Save *YOU?*

To find out how the new capacity ratings affect the types and sizes of Timken bearings in which you are interested, call your Timken bearing representative or write our Engineering Department. We'll be glad to work with you at the drawing board stage. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

TAPERED ROLLER BEARINGS ROLL THE LOAD

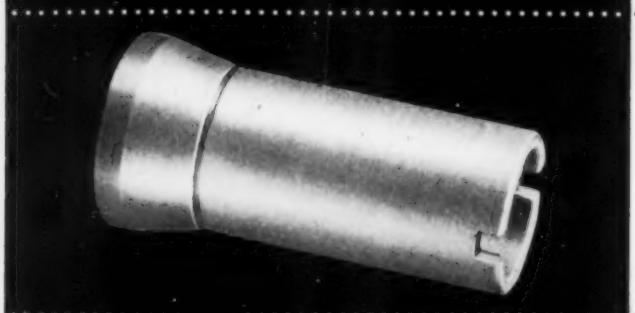
Designers! Whether you figure

Adjusting Knob for Room Thermostat

Cost/M Brass $16.10
Aluminum . . . 9.44

*Savings Based On 1000 Parts**

41.3% **$6.66**

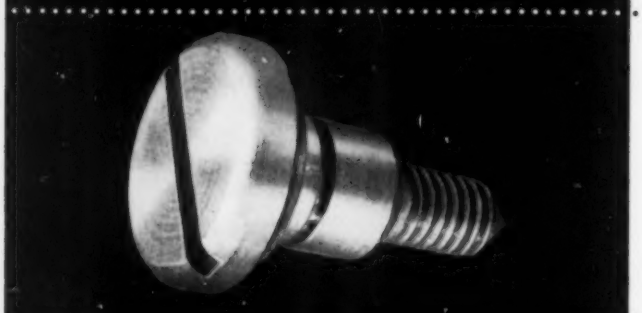


Cover Screw for "Protecto Relay" Unit

Cost/M Brass $16.80
Aluminum . . . 10.80

*Savings Based On 1000 Parts**

35.7% **$6.00**

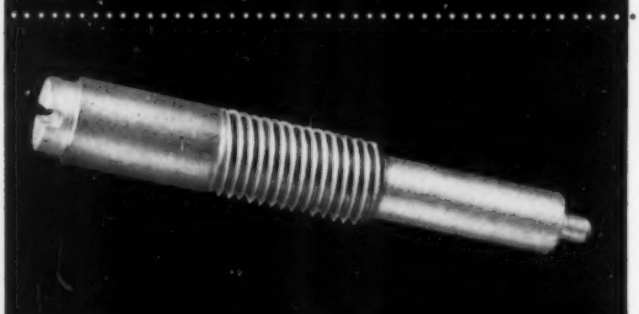


Tension Nut for "Immersion Aquastat"

Cost/M Brass $9.10
Aluminum . . . 4.50

*Savings Based On 1000 Parts**

50.5% **$4.60**



Adjusting Screw for "Immersion Aquastat"

Cost/M Brass $11.90
Aluminum . . . 7.33

*Savings Based On 1000 Parts**

38.5% **$4.57**

Packing Nut for Temperature Controller Unit

Cost/M Brass $33.60
Aluminum . . . 21.45

*Savings Based On 1000 Parts**

36.2% **$12.15**

NOTE: Tooling costs and machining times are comparable for both brass and aluminum

savings in per cents or dollars,

conversion from brass to aluminum screw machine parts adds up to real economy! For example, these five conversions saved Minneapolis-Honeywell Regulator Company 36.7 to 50.5 per cent per part . . . or a total of $7,720* a year! All five parts run at maximum efficient speed on present machines with little or no change in tooling or equipment . . . why not let a Kaiser Aluminum engineer help you get savings like these in

Kaiser Aluminum

For complete information and expert assistance, call one of our many distributors, or look for our local number in your classified telephone directory.
Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office,* Palmolive Bldg., Chicago 11, Ill.; *Executive Office,* Kaiser Bldg., Oakland 12, Calif.

Recommended by Managements

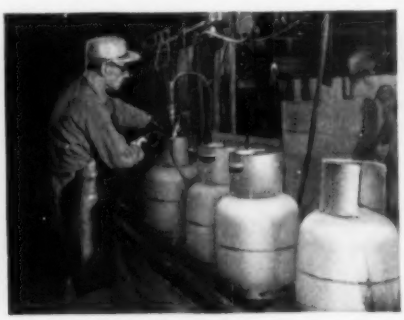
Specified by Designers

Preferred by Operators

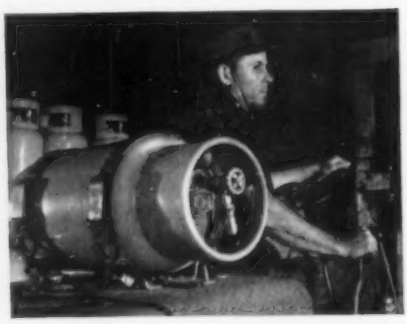
***Savings based on metal prices current when the conversion was made.**

Here N-A-X FINEGRAIN *steel proves its versatility, forming readily under the deep-drawing operation that pressure cylinder manufacturing requires. For 20-lb. cylinders, .086"* N-A-X FINEGRAIN *blanks, 21¼" in diameter, become 12" in diameter and 7½" in depth after the drawing operation. Steel Cooperage Division produces cylinders up to 425-pound capacity.*

Submerged arc welding operation joins the two cylinder sections together. N-A-X FINEGRAIN *again demonstrates its weldability under any process.*



Here cylinder pressure capacities are tested hydrostatically at 480 lbs. psi, after the fittings have been added. Final burst pressure—1650 lbs. psi.



Finished product on the job. This cylinder, meeting all specifications of I.C.C. code, Section 4BA, contains liquefied petroleum for materials handling truck.

For whatever you make . . .

N-A-X® FINEGRAIN STEEL BUILDS IN STRENGTH WITH LIGHT WEIGHT

A significant example of the strength, formability and weldability of N-A-X FINEGRAIN steel is to be found in the manufacture of liquefied petroleum gas cylinders by Steel Cooperage Division of the Serrick Corporation, Detroit.

These lightweight LP-Gas cylinders must be able to withstand high internal pressures. Therefore, the steel used in their manufacture must have a minimum yield strength of 50,000 pounds per square inch and a tensile strength of 70,000 pounds per square inch, in order to meet the requirements of Section 4BA of the I.C.C. specifications.

On this job, as with so many others, N-A-X FINEGRAIN steel resulted in lighter weight, without sacrifice of strength and safety.

Check these important advantages for your job: N-A-X FINEGRAIN steel, compared with carbon steel, is 50% stronger • has high fatigue life with great toughness • is stable against aging • has greater resistance to wear and abrasion • is readily welded by any process • offers greater paint adhesion • polishes to a high luster at minimum cost. And the physical properties of N-A-X FINEGRAIN are inherent in the "as rolled" condition. N-A-X FINEGRAIN'S resistance to normal atmospheric corrosion is twice that of carbon structural steel. NOTE: Where greater resistance to extreme atmospheric corrosion is an important factor, our N-A-X HIGH-TENSILE is recommended.

For whatever you make, from pressure cylinders to tractors, with N-A-X HIGH-STRENGTH steels you can design longer life, and/or less weight, and economy, into your products. Let us show you how.

N-A-X HIGH-STRENGTH STEELS

N-A-X Alloy Division, Dept. C-5

GREAT LAKES STEEL CORPORATION

Detroit 29, Michigan • Division of

NATIONAL STEEL CORPORATION

N-A-X Alloy Div., Dept. C-5
Great Lakes Steel Corp., Detroit 29, Michigan

☐ Please send me technical data on N-A-X FINEGRAIN steel.
☐ Please have your representative contact me.

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immediate shipment . . . all ratings

General Electric TRI 55 CLAD

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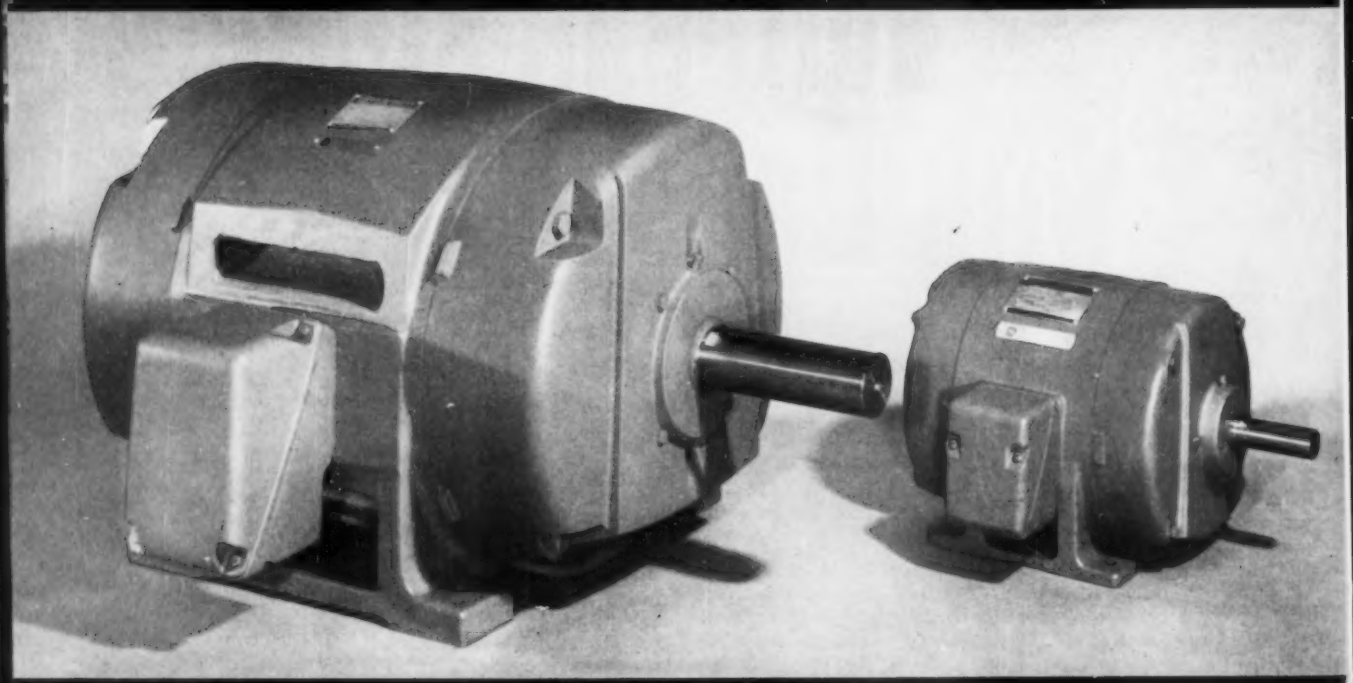
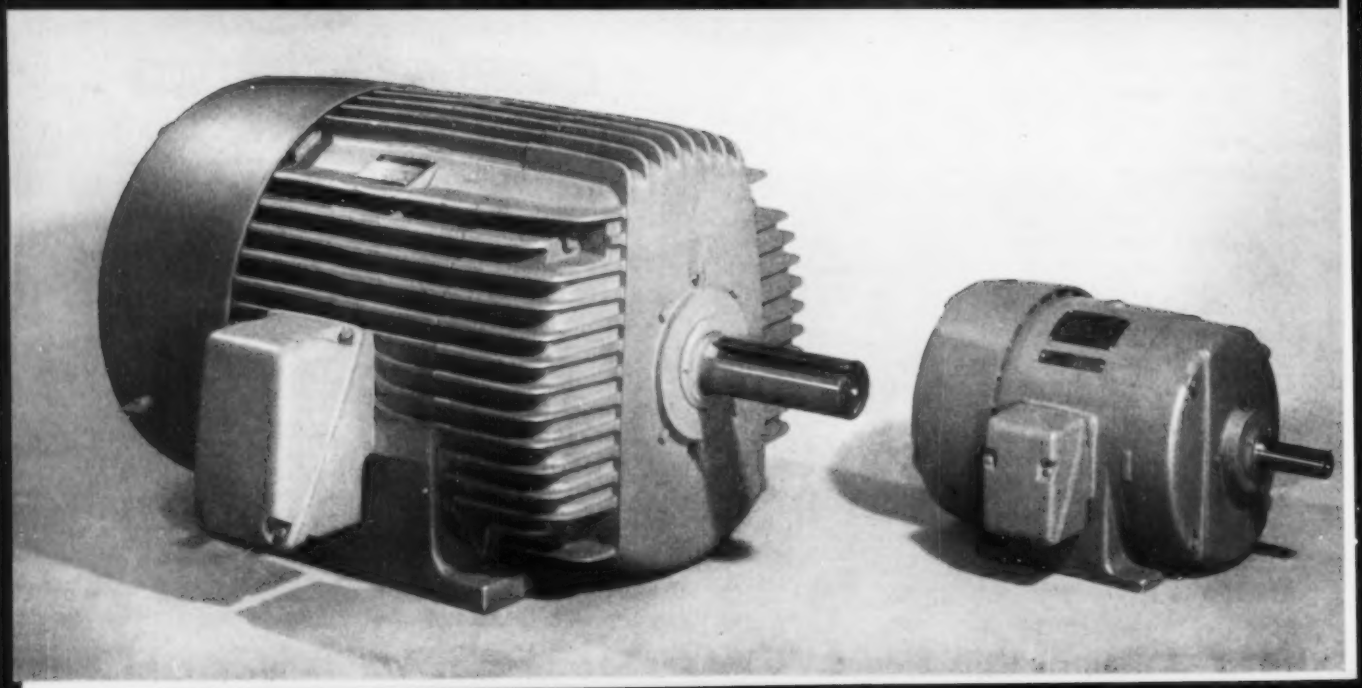


TOTALLY ENCLOSED

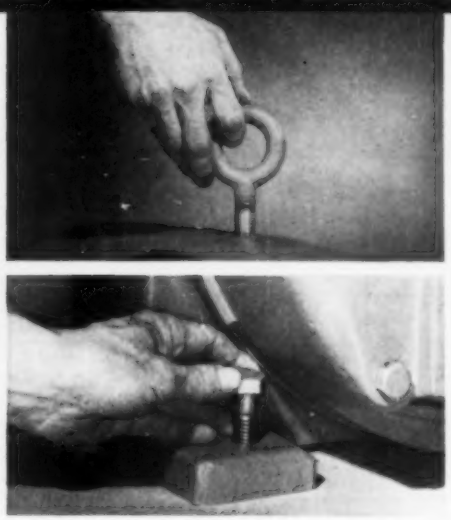


Motors in New NEMA Ratings

TO 125 HP

YEARS AHEAD BENEFITS

DESIGNED TO CUT COSTS—Up to 32% lighter and 50% smaller, new NEMA rated Tri-Clad '55' motors offer big savings on shipping, handling and storage costs. These more powerful, more compact motors permit big space savings on many machine designs.



DESIGNED FOR EASY HANDLING—Sturdy, forged eye bolts are supplied with new Tri-Clad '55' motors in larger ratings to permit easier motor handling. Provision for plenty of "wrench room" between motor feet and end shields cuts Tri-Clad '55' motor mounting time.

DESIGNED FOR EASY INSTALLATION—Perma-numbered leads simplify wiring and speed motor hook-up. Numbers are stamped on terminals and printed on every half inch of the Geoprene® lead covering. Leads are always identifiable even when taped or clipped.

FOR COMPLETE INFORMATION

FOR COMPLETE DETAILS on the new line of Tri-Clad '55' motors up to 125 hp, contact your local G-E motor distributor or the sales engineer at your nearby General Electric Apparatus Sales Office. You will get expert assistance in selecting and applying the right motor for your particular application.

FOR FREE SLIDE RULE—which lets you determine at a glance the weight and space-saving benefits of recently announced NEMA standards for larger motors—and for informative, free General Electric Tri-Clad '55' motor bulletin, please send attached coupon.

Section 891-6A
GENERAL ELECTRIC COMPANY
Schenectady 5, New York

Please send me the following publications:

☐ **FREE BULLETIN** (GEA-6602) describing the many advanced features of new Tri-Clad '55' motors up to 125 hp.

☐ **FREE SLIDE RULE** (GEN-148) to determine weight and space-saving benefits of new Tri-Clad '55' motors.

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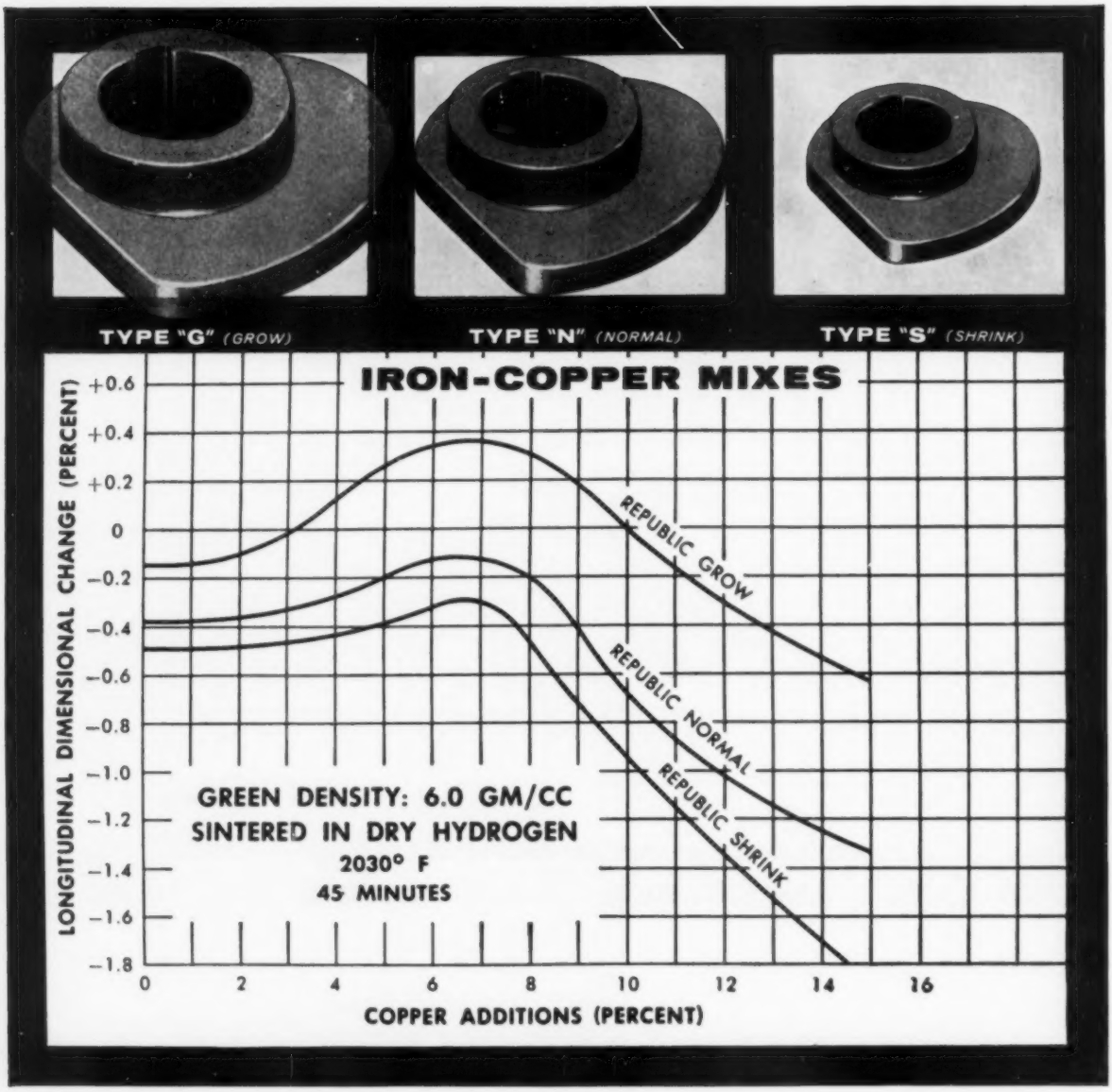
Progress Is Our Most Important Product

GENERAL ELECTRIC

Republic Iron Powders



REPUBLIC

REPUBLIC STEEL

World's Widest Range of Standard Steels

with cdf

aid in establishing finish dimensions of parts

The chart, at left, shows the distinct dimensional change-characteristic that occurs when any one of Republic's three new Iron Powders —Type "G" for growth, Type "N" for normal, Type "S" for shrinkage—is blended with varying amounts of copper.

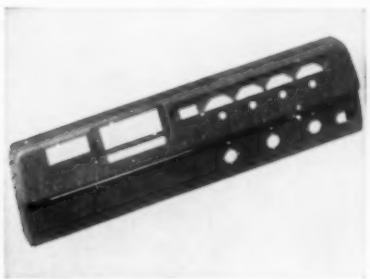
This change-characteristic is called *Controlled Dimensional Factor*—an exclusive Republic development.

All values in this chart represent the average of numerous tests conducted by Republic's Metal Powder Division in the development of these new types of iron powder. In all cases, one percent zinc stearate was used as lubricant.

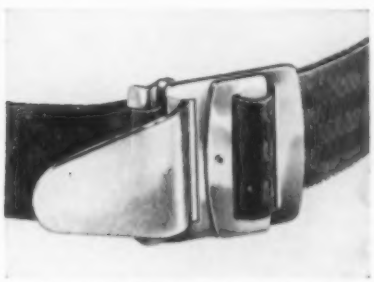
Republic Iron Powders with CDF can aid you in establishing the finish dimensions of parts. They can help you make better parts, reduce fabricating costs, and save on expensive die re-working.

Our metallurgists and engineers will help you utilize all the advantages of Republic Iron Powder with CDF. There is no obligation. Mail the coupon to obtain their services or for more information on test evaluations, chemical compositions, and physical properties.

BETTER TUBULAR PARTS are made with Republic ELECTRUNITE® Welded Steel Tubing. Harper-Wyman Company uses it in making lightweight, easy-to-clean venturi burner tubes. The company subjects ELECTRUNITE to a hairpin bend of 1¼-diameter radius, then a four-way crimp, followed by punching, notching and welding. Uniform, predictable ductility avoids stretch and collapse as tubing is severely bent and formed. Close tolerances of O.D. and I.D. avoid die and mandrel troubles. Write for facts.



QUALITY STAMPED AND DRAWN PARTS such as this electric range control panel are produced by Republic's Pressed Steel Division. Complete service is provided from design to fabrication. Topnotch facilities, plus years of know-how and experience, assure you of the best product. Equipment is available for blanking, cold and hot forming, drawing—also for complete assemblies. We handle the heaviest gages used in industry, including carbon and alloy steel or nonferrous metals. Write for Booklet Adv. 681.



STRONG, SAFE PARTS are fabricated from Republic ENDURO® Stainless Steel. Bunke-Musser Company uses Type 201 for this seat-belt buckle. Fabricating operations include shearing, punching, and severe bend of 175° to form the pelican hook. The company had tried carbon steel, but this required a heavier gage, chrome plating and polishing, with the end result being more expensive than stainless. Republic Type 201 provides strength, safety, wear-resistance, and workability. Write for booklet on the 200-Series stainless steels.

STEEL

and Steel Products

REPUBLIC STEEL CORPORATION
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☐ Send more information on Republic Iron Powders with CDF.
☐ Have an engineer call.
Send additional information on:
☐ ELECTRUNITE Welded Steel Tubing ☐ Stampings
☐ ENDURO Stainless Steels (200 Series)

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helps assure
customer satisfaction
by using

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MOTOR PROTECTORS

"A. O. Smith customers insist on the best. We insist on supplying the best. One of the many ways we make sure our customers have the finest is through use of quality products for motor protection. The jet pump fractional motor shown is only one of thousands of A. O. Smith Fractional and Integral Horsepower motors using KLIXON Protectors. This is a sample of our slogan — 'Through Research A Better Way.'"

That's how C. M. Poston, Sales Manager of A. O. Smith Corporation's Electric Motor Division, feels about KLIXON Motor Protectors — another famous motor manufacturer who counts on KLIXON Protectors for maximum motor performance with minimum motor failures.

You, too, can keep motors in your equipment operating dependably, reduce service calls and repairs by specifying and using KLIXON Protectors. The additional cost is low, pays for itself over and over by keeping motors delivering maximum output under any operating condition while protecting against motor burn-outs and unnecessary equipment shutdowns.

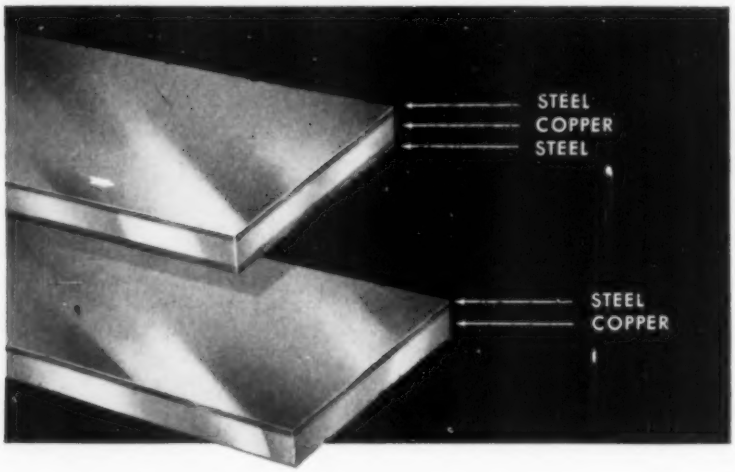
Now There's Something New!
In addition to the famous KLIXON Protector for single-phase motors, you can now get full protection engineered into 3-phase motors with a single, built-in KLIXON Protector. For full details write for Catalog Sheets MOPR-1, MOPR-5B, MOPR-11A.

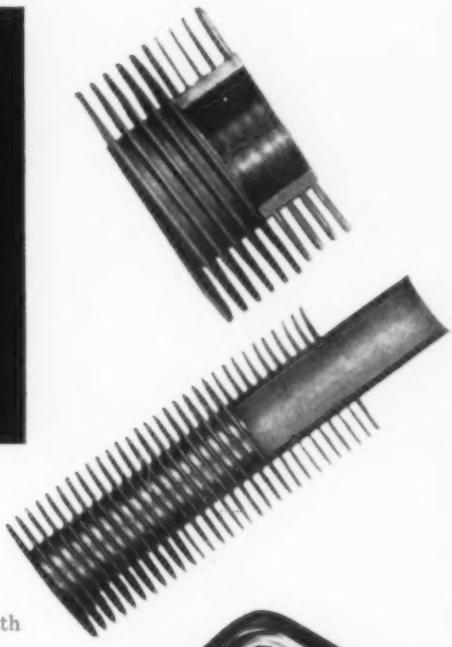
METALS & CONTROLS CORPORATION
Spencer Thermostat Division
3808 Forest Street, Attleboro, Mass.

KLIXON®

General Plate's

Stainless Clad Copper Combines Desirable Properties of Copper and Stainless To Offer New Advantages



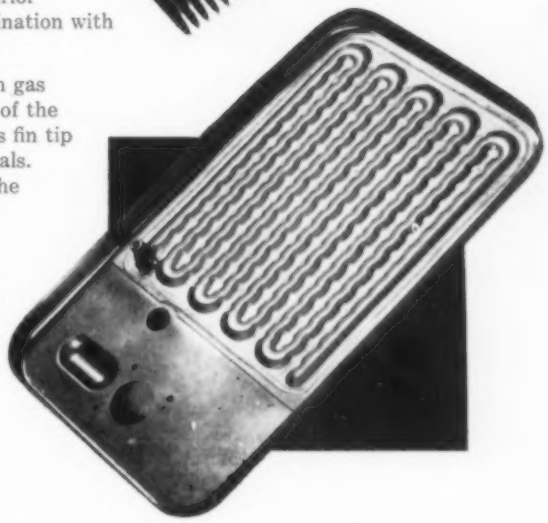


When two or more metals are clad into sheet, desirable properties of each are combined to produce a material having new and useful characteristics not present in either metal separately.

Thus General Plate's Stainless Clad Copper offers the superior thermal and electrical conductivity of pure copper in combination with the high temperature corrosion resistance of stainless steel.

For example, in finned heat exchangers designed to work in gas temperatures up to 2600°F, the high thermal conductivity of the copper core in General Plate Stainless Clad Copper reduces fin tip temperatures by 20% to 30% compared to solid fin materials. There is a corresponding increase in fin efficiency, and at the same time the austenitic stainless steel cladding gives the fins substantially greater oxidation resistance, greatly increasing their life.

General Plate Stainless Clad Copper is available in widths up to 13" and thicknesses up to 1/16", single or double clad, in long lengths. It can be blanked, drawn, spun, formed, brazed, and spot or seam welded.



Typical products made from General Plate Stainless Clad Copper

Let us send you complete information on General Plate Stainless Clad Copper . . . it may be just what you have been looking for. Write today for Catalog Sheet 727C — no obligation.

METALS & CONTROLS CORPORATION
General Plate Division
1008 Forest Street, Attleboro, Mass.

structurally homogeneous

PARKER-KALON stress relieved socket screws

After controlled heating and equally controlled uniform quenching imparting maximum strength, P-K Socket Screws are carefully tempered to assure ductility, proper elongation and high impact strength. This is your assurance that . . . *If it's P-K . . . It's O-K!*

PARKER-KALON DIVISION, General American Transportation Corporation • Manufacturers of Socket Screws, Self-tapping Screws, Screwnails, Masonry Nails, Wing Nuts and Thumb Screws.

Sold Everywhere Through Leading Industrial Distributors — Factory: Clifton, New Jersey • Warehouses: Chicago, Illinois; Los Angeles, California

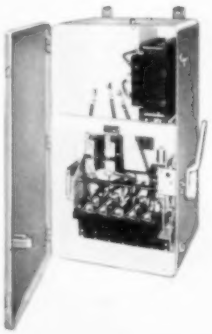
PARKER-KALON® fasteners

the only complete line of reduced voltage STARTERS

For SATISFYING Power Company and Application Requirements . . .

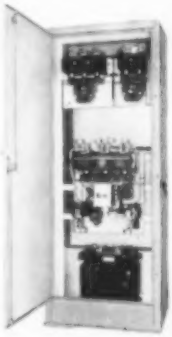
BULLETIN 646
manual autotransformer TYPE

A strictly "modern" starter. Silver alloy, *air break* contacts provide long, trouble free life . . . without the messiness and maintenance of oil-immersed contacts. Operation is simple . . . a bell signals proper interval—which can be adjusted—for switchover from START to RUN. Air break contacts standard in ratings to 75 hp, 220 v; 150 hp, 440-550 v. Also furnished oil-immersed up to 125 hp, 220 v; 250 hp, 440-550 v.



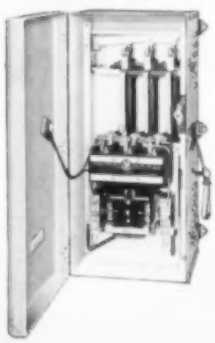
BULLETIN 746
automatic autotransformer TYPE

Employs autotransformer connected in delta to reduce line voltage for starting squirrel cage motors that should not be started on full line voltage. Automatically operated by solenoid contactors with double break, silver alloy contacts. Adjustable timing relay controls accelerating period. Taps are provided on the autotransformer to adjust the motor starting voltage. Ratings up to 300 hp, 220 v; 600 hp, 440-550 v.



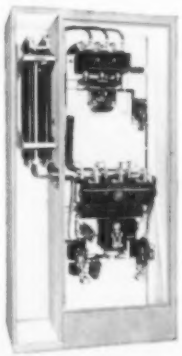
For Velvet S-M-O-O-T-H STARTING . . . nothing equal on the market!

BULLETIN 640
manual stepless resistance TYPE



Graphite compression disc resistors provide smooth, stepless starting of polyphase squirrel cage motors. Operated by hand lever, the smooth starting of the motor is under the control of the operator. Limits starting current and prevents lamp flicker. Accurate overload relays protect motors against burnout. No-voltage protection provided. Ratings to 200 hp, 220-440-550 v.

BULLETIN 740
automatic stepless resistance TYPE



Preset and adjustable graphite disc resistors are automatically inserted in series with squirrel cage motor at starting. Adjustable timing relay operates contactor, which automatically cuts out resistors after predetermined starting period. Resistors can be adjusted to motor and load conditions for velvet smooth acceleration. Accurate thermal relays protect motors. Ratings to 200 hp, 220-440-550 v.

8-57-MR

A-B Quality

Write for Bulletin

Allen-Bradley Co.
1316 S. Second St.
Milwaukee 4, Wis.

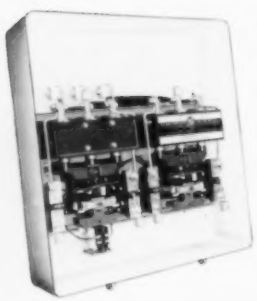
In Canada—
Allen-Bradley
Canada Ltd.
Galt, Ont.

ALLEN-BRADLEY
MOTOR CONTROL
QUALITY

see next page

...and still other ALLEN-BRADLEY reduced voltage STARTERS

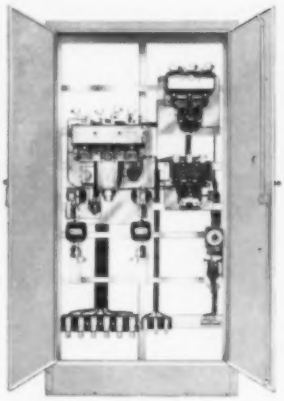
BULLETIN 736...AUTOMATIC part winding TYPE



For use with squirrel cage motors having two separate parallel stator windings. Provides economical reduced voltage starting when starting current does not exceed power company limitations. Two types—Style A is a 2-step starter available in ratings up to 200 hp, 220 v; 400 hp, 440-550 v. Style B is a 3-step starter with resistance in series with the motor on the first step. In ratings up to 200 hp, 220-440-550 v.

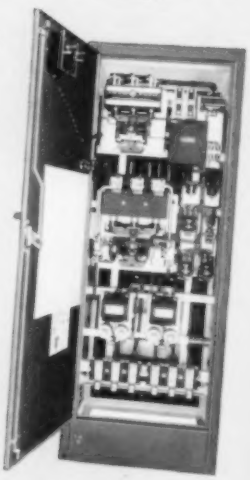
BULLETIN 741...AUTOMATIC multipoint resistance TYPE

An automatic starter that will satisfy power company requirements for starting of motors on network systems. Resistances are automatically inserted in the line at starting, and are short circuited in steps at definite time intervals. Time intervals can be adjusted from 1 to 5 seconds for ideal starting under various load conditions. Available in 2, 3, and 4-point starters. Made in ratings up to 300 hp, 220 v; 600 hp, 440-550 v.



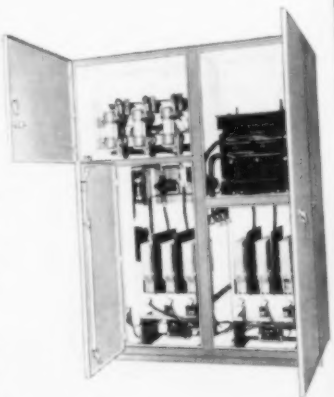
BULLETIN 742...AUTOMATIC stepless, graphite resistance TYPE

This is the ultimate in smooth acceleration of squirrel cage motors. The graphite disc resistors vary in resistance smoothly and steplessly as the pressure on them is automatically changed. Also, the rate at which pressure is applied can be varied over a wide range. Lamp flicker on network systems used for both power and light is completely eliminated. Also ideal where a starting shock to driven machines may cause serious trouble or affect machine life. Ratings to 200 hp, 220-440-550 v.



BULLETIN 1172...AUTOMATIC high voltage, air break reactor TYPE

For starting high voltage squirrel cage motors at reduced voltage. Simple solenoid air break contactor has only *one* moving part, and the double break, silver alloy contacts need no maintenance. These contactors are designed for heavy duty industrial service and can be used for inching or jogging. Reliable overload relays protect the motor at all times. Starters have interrupting capacities of 150,000 kva, 2300 v; 250,000 kva, 4600 v. Made in ratings up to 1500 hp, 2300 v; 2500 hp, 4600 v.



A-B Quality

ALLEN-BRADLEY

QUALITY

MOTOR CONTROL

Allen-Bradley Co.
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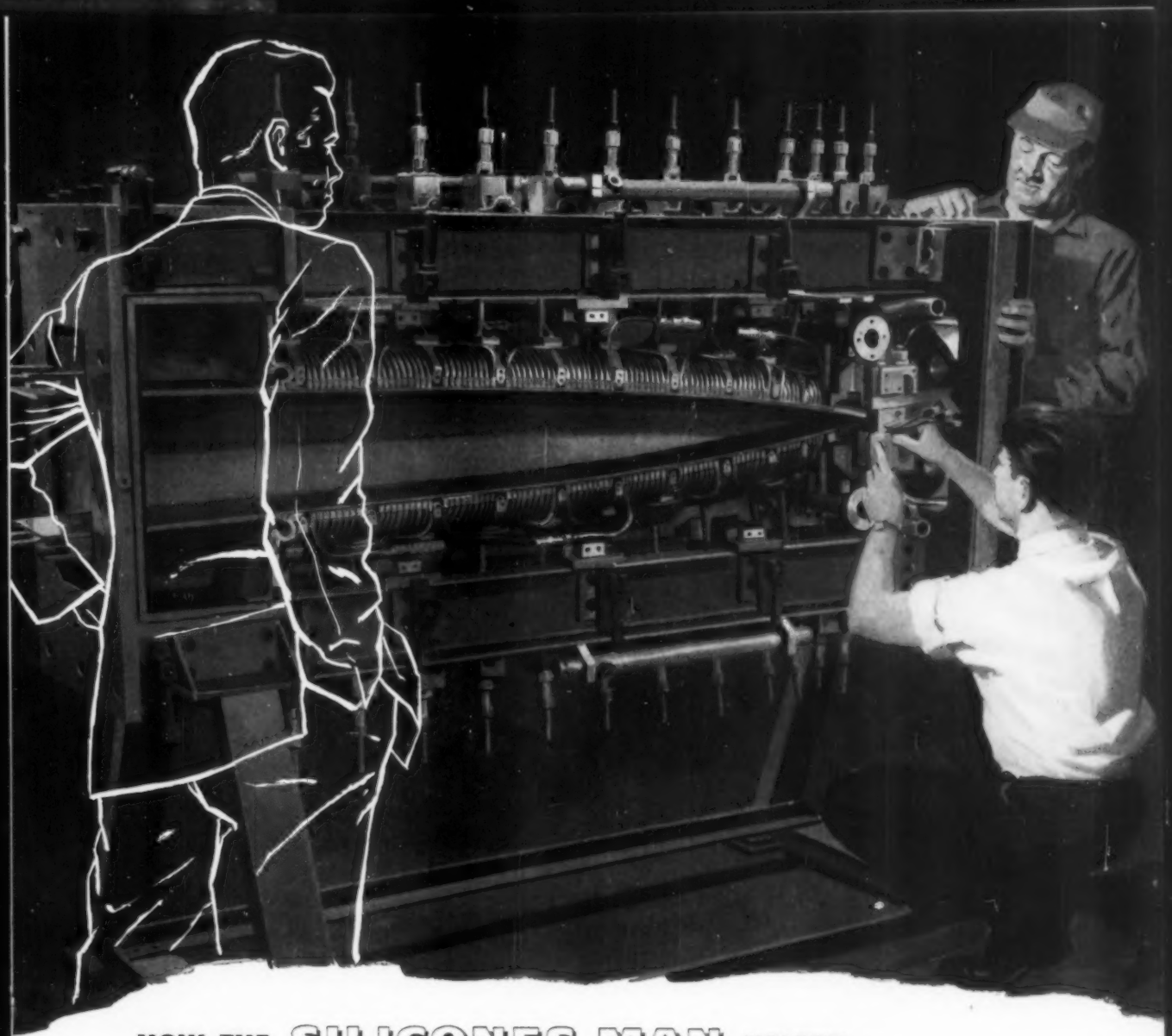
8-57-MR



HOW THE SILICONES MAN HELPED...

CHANGE THE TUNE OF A MACH 5 WHISTLE

Ram a wind thirty-six hundred miles an hour down a wind tunnel 20 inches square. Problems in testing models of supersonic rockets and missiles in such a tunnel gave new dimensions to operational techniques.

Developed by engineers of the Jet Propulsion Laboratory at California Institute of Technology, this advanced wind tunnel presented many unique problems. In order to control the air going into the test section, movable plates were used to vary the area of the opening. The plates, moving against one another, had to be sealed. The abrasion created by this movement destroyed ordinary sealing materials. That is, until UNION CARBIDE Silicone Rubber was used. Fabricated by Reeves Rubber, Inc., of San Clemente, California, in solid strips . . . in hollow tubing that is pressurized for an extra tight fit . . . this silicone rubber performed exceptional service under almost "impossible" conditions. In fact, tests indicate that maintenance will only be required once every two or three years!

This is another example of how the UNION CARBIDE Silicones Man has helped solve an "impossible" problem. A booklet—"Look to UNION CARBIDE for Silicones" describes silicone rubber and many other silicone products. **Write Dept. P-8 today.** Silicones Division, Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.

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In Canada: Bakelite Company, Division of
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Always, at SKF, you will receive unbiased advice

because

– All four basic types of anti-friction bearings are available from **SKF**.

because

– They offer an extraordinarily wide range of sizes and combinations to meet virtually any requirement.

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– Their long experience in the widest variety of bearing applications is your assurance of receiving sound recommendations.

because

– Thousands of manufacturers have been using the **SKF** Bearing Advisory Service for many years – always with good results. This dependable service is available to you, too. 7754

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SOCKET SCREWS
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X-RAY UNITS PERFORM A COMPLETE AND ACCURATE METAL ANALYSIS

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For the finest in socket screw products . . . for unmatched SAME-DAY SERVICE—the name to remember is Holo-Krome. Write for free catalog and technical information.

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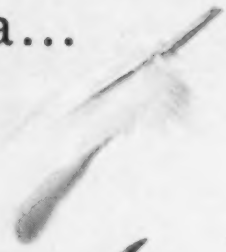
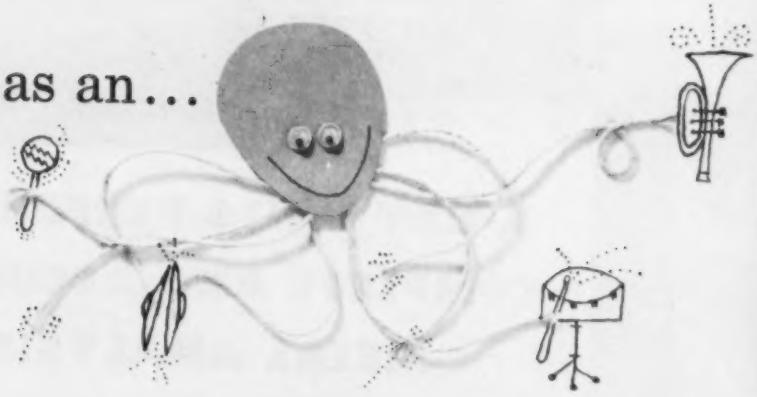
What's light as a...



strong as a...

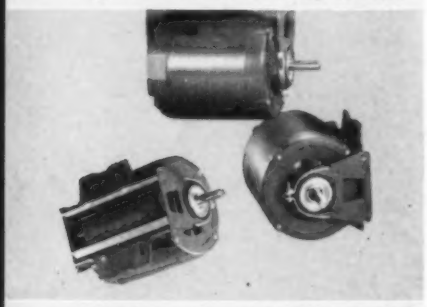
quiet as a...

versatile as an...

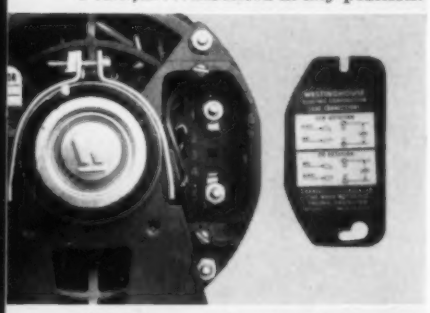


The 48·frame motor by Westinghouse!

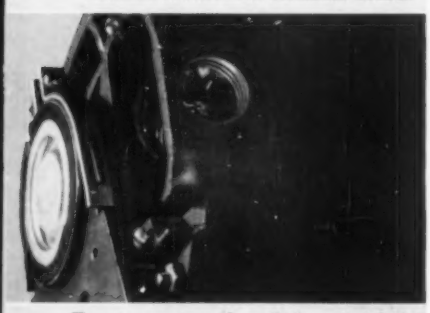
Light as a feather . . . by up to 50%!



Powerful . . . mounted in any position!



Versatile . . . modern terminal board!



Easy to mount . . . threaded conduit hole!

Dependable . . . because it's Westinghouse!

What do you look for in an FHP Motor?

Whether you are a manufacturer, designer, buyer or engineer, there are certain features you look for when you buy fhp motors. You want a motor that is light . . . powerful . . . compact . . . quiet . . . and long lasting.

These are just a few of the features you get in 48-frame motors by Westinghouse! Feature by feature, there are no finer motors on the market! Don't take our word for it . . . compare. Here are the facts . . .

Fact 1: The Westinghouse 48-frame is up to 50% *lighter* than motors of comparable power! For *you* this means lighter equipment, reduced shipping costs.

Fact 2: The Westinghouse 48-frame gives you *true* all-position mounting. Positive oil return system provides excellent lubrication in any position.

Fact 3: The Westinghouse 48-frame gives you spade mounting (plug-in), standard terminal stud connections, and shur-plug for changing rotation.

Fact 4: The Westinghouse 48-frame threaded conduit hole assures faster assembly on your production lines, fewer connector parts and *positive* connections.

Fact 5: The Westinghouse 48-frame *is Westinghouse!* This distinctive tag is your guarantee of quality, performance, and long life.

Want More Facts? Call your nearest Westinghouse sales engineer, or get your copy of the 48-frame booklet giving all the features in detail. Just fill out and mail this coupon . . .

J-03034

YOU CAN BE SURE . . . IF IT'S

Westinghouse

Small Motor Division, Lima, Ohio.

WESTINGHOUSE ELECTRIC CORPORATION
Small Motor Division, P. O. Box 566
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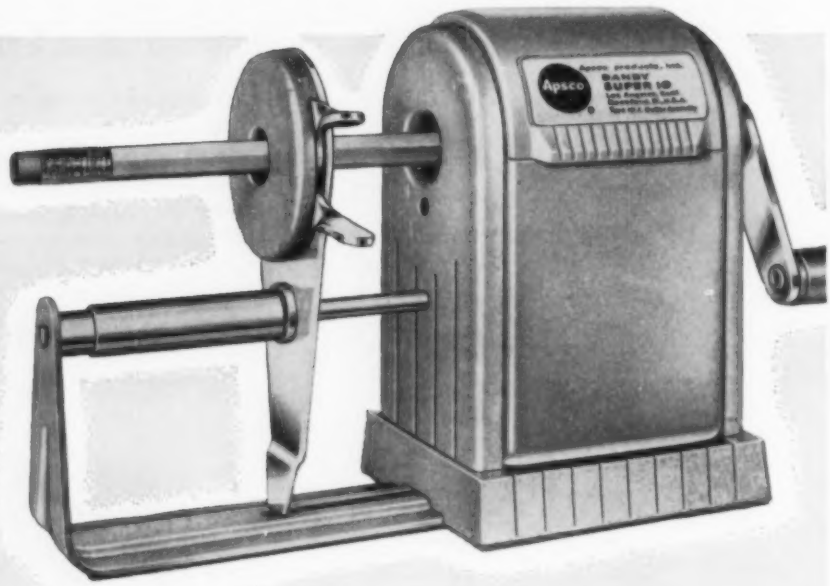
WHY CYCOLAC®
HIGH-IMPACT THERMOPLASTIC RESIN

...in the new APSCO pencil sharpener line?

. . . the answer is simple:

Trade and consumer acceptance of Apsco's line of pencil sharpeners with receptacles of CYCOLAC was so instantaneous and overwhelming that this firm, the oldest in its field, converted their entire line to CYCOLAC. In addition to providing tremendous advances in design and engineering, CYCOLAC also offered high-impact, dimensional stability, high tensile, compression and shear strength.



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now more competitively priced than ever!

Spiraling demand and greatly expanded manufacturing facilities have enabled Marbon Chemical to effect production economies which they are passing on to their customers. The new price adjustments, which went into effect on July 1, 1957, make CYCOLAC ABS Polymer more attractive, more desirable, more practical for a host of end-use products.

CYCOLAC has the very basic material properties you are looking for: rugged toughness plus light weight . . . bright colors accented by high gloss . . . excellent impact-resistance combined with a high in heat-distortion temperature plus a low brittle point.

CYCOLAC has greater dimensional stability . . . wonderful electrical properties and is easily injection-molded, extruded or calendered.

CYCOLAC is resistant to many oils, solvents and corrosive chemicals . . . capable of being colored to hundreds of opaque shades . . . and can be readily machined.

Write For The NEW CYCOLAC Price Schedule Today!

MARBON CHEMICAL
Division of BORG-WARNER
GARY, INDIANA

MARBON CHEMICAL . . . *Precision Resins for Precision Made Products*

GET SQUARE D SAFETY SWITCHES AND BENEFIT FROM THE NEW NEMA STANDARDS

NEMA standards are adopted in the public interest and are designed to eliminate misunderstandings between the manufacturer and the purchaser, as well as to assist the purchaser in selecting and obtaining the proper product for his particular need.

Square D's quick change to the new standards gives you the performance and safety which NEMA standards assure.

Square D Safety Switches cost no more —why settle for less?

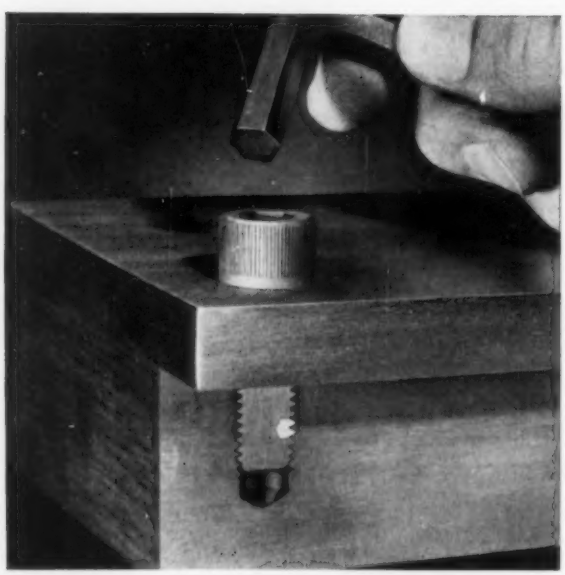
DESCRIPTION	HEAVY DUTY New	NORMAL DUTY formerly Types H, S, or A	LIGHT DUTY formerly Types D or G
Rating-Ampere Voltage	30—600 250 or 600V AC, DC	30—1200 250 or 600V AC, DC	30—200 250V AC
Enclosure	NEMA 12 • Industrial Use (Gasketed) NEMA 4 & 5 • Water-tight & Dust-tight NEMA 7 • Explosion-resisting Class I—Group D NEMA 9 • Explosion-resisting	NEMA 1 • General Purpose NEMA 3R • Raintight	NEMA 1 • General Purpose NEMA 3R • Raintight
Horsepower Rating	NEC Fuse Ratings Dual-Element Fuse Ratings	NEC Fuse Rating Dual-Element Fuse Ratings	NEC Fuse Rating
Operating Mechanism	Quick-Make, Quick-Break Independent of Handle	Quick-Make, Quick-Break Independent of Handle	Positive Make, Positive Break Spring Assisted
Cover	Interlocked & Padlock Attachment	Interlocked & Padlock Attachment	Padlock Attachment
Plating—Current Parts	Extra-Heavy Silver	Silver	
Endurance	Maximum Endurance Far Exceeds UL Standards	Exceeds UL Standards	Meets UL Standards

NOW...EC&M PRODUCTS ARE A PART OF THE SQUARE D LINE

SQUARE D COMPANY

The ordinary fasteners securing the worm wheel to the drum shaft in this automatic screw machine loosened, causing $120 worth of damage to parts. Labor for the repair job cost $100. The ordinary fasteners were replaced with self-locking UNBRAKOS, and there has been no trouble since.

Vibration won't loosen self-locking UNBRAKO socket cap screws



HOW IT LOCKS. The tough, resilient Nylok locking pellet keys itself into the mating threads. It forces threads together and locks the screw securely—whether or not the screw is seated.

UNBRAKO socket screws with the Nylok* self-locking device eliminate fastener problems caused by vibration.

Take the drive system in the automatic screw machine illustrated above, for example. The screws originally used to secure the worm wheel to the drum shaft loosened, causing considerable damage, besides loss of production time. These have now been replaced with self-locking UNBRAKO socket head cap screws and the trouble has been eliminated.

An UNBRAKO socket screw with the Nylok self-locking device is a single unit. Just screw it into any tapped hole. Seated or not, it locks positively wherever wrenching stops. Constant vibration or endless running of a machine won't affect these self-locking UNBRAKOS. The screws will not work loose!

Write today for your copy of Form 2193, which gives catalog and technical data on the complete line of UNBRAKO socket screws with the Nylok self-locking device. Or see your local industrial distributor. Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 28, Pa.

UNBRAKO® SOCKET SCREW DIVISION

STANDARD PRESSED STEEL CO.

SPS

JENKINTOWN PENNSYLVANIA

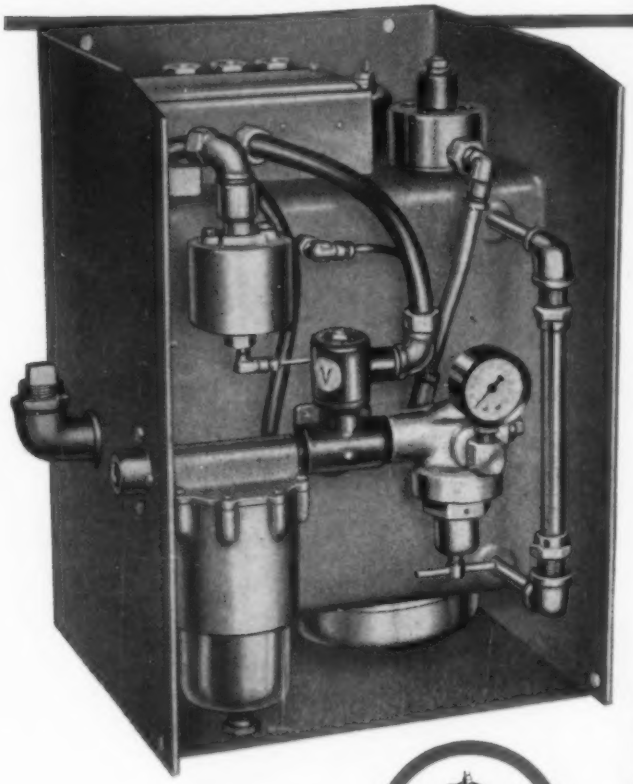
*T.M. Reg. U.S. Pat. Off., The Nylok Corporation

NOW! An Automatic Lubrication System with

300-500
bearing inch capacity

Oil-Mist Unit atomizes oil and distributes it through tubing to all lubricated mechanisms.

ALEMITE oil-mist



provides safe–sure–continuous–foolproof lubrication!

- **Large Models Designed for Large Machines!** Designed to lubricate up to 500 Bearing inches. (1 Bearing Inch equals 1 inch of Shaft Diameter.)
- **Big Lubricant Supply!** 3-gallon capacity tank holds enough oil to provide a "48-hour week" of continuous lubrication for 500 Bearing Inches.
- **Extensive Coverage!** System is efficient in small, compact installation or extended over a distance of 480 feet.
- **Multiple Controls!** Automatic controls regulate air pressure, Oil-Mist delivery, check system operation and guard oil level.

Alemite Oil-Mist Lubricates all types of mechanisms

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- ☐ Please send me a FREE copy of your new and complete Alemite Oil-Mist catalog.
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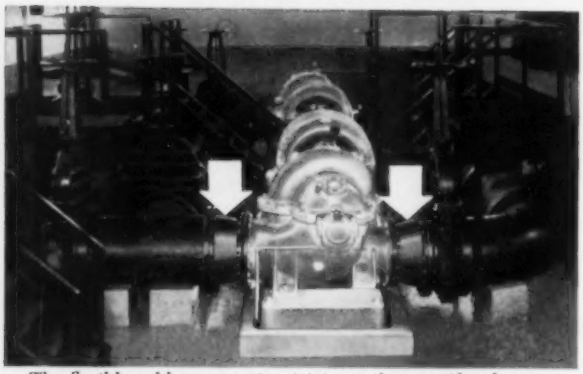
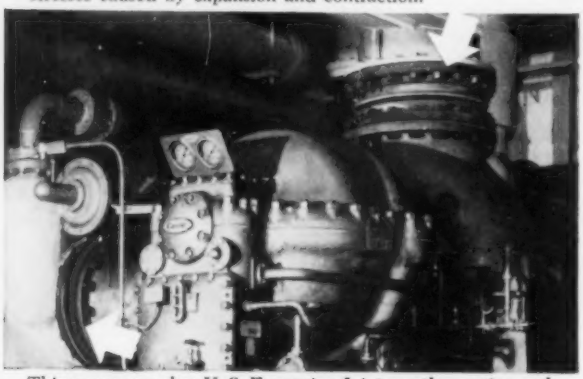
EXPANSION JOINTS

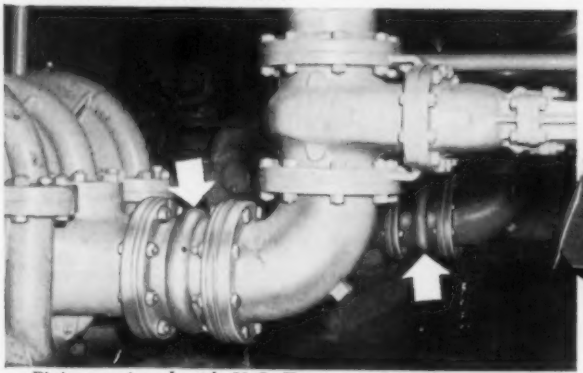
Expanding the Designer's Scope



The flexible rubber expansion joints on the centrifugal pump installations (above) are made by U. S. Rubber. They prevent stresses caused by expansion and contraction.



This compressor has U. S. Expansion Joints on the suction and discharge lines. Like all U. S. Joints, these insulate against the transfer of vibration and noise.



Piping equipped with U. S. Expansion Joint to compensate for any misalignment caused by load stresses, wearing of parts or settling of building.

U. S. Rubber Expansion Joints are resilient and therefore do not, like metal, set permanently when compressed. Constant flexing merely keeps them alive... prevents brittleness.

- They absorb both axial and lateral deflection far more than metal joints. Greater insulation against vibration and pump noises. No electrolysis, corrosion or erosion.
- Handle pressures from 40 lbs. to 125 lbs.
- The outside diameter of the arch is smaller than on metal joints. (Face-to-face dimensions, even with multiple arches, are smaller.)
- Weight is much less. This, plus the fact that no gasket is needed between flanges (metal joints require gaskets) results in an easier installation lowering the cost.

"U. S." was the *first* to develop expansion joints. They are at work in every kind of industry, prolonging the life of equipment in pressure or vacuum pipe systems. Some are still in service, after 30 years of operation. Obtainable at any of the 28 "U. S." District Sales Offices, or write us at Rockefeller Center, New York 20, N. Y. In Canada, Dominion Rubber Co., Ltd.

For the complete technical information catalogue on the entire line of U. S. Rubber Expansion Joints, contact your nearest "U.S." District Sales Office or write us at Rockefeller Center, New York 20, New York.

Mechanical Goods Division

United States Rubber

Your automated production line will be made more efficient by using Eaton-Reliance Springtites and Sems for assemblies. Preassembly of screws and washers eliminate expensive hand operations — thus speeding production. In addition, the freely rotating, nonremovable washer exerts constant reactive pressure to keep bolted assemblies tight.

These time-tested fasteners will save production time, simplify inventory problems and reduce waste through loss.

Eaton-Reliance Springtites and Sems are being used to advantage on fast moving production lines in the automotive, appliance, farm machinery, and road building equipment industries . . . just about any place where speed, efficiency and quality spell p-r-o-f-i-t-s. Write for your free copy of Engineering Bulletin S-49, or ask for a visit from one of our fastening engineers.

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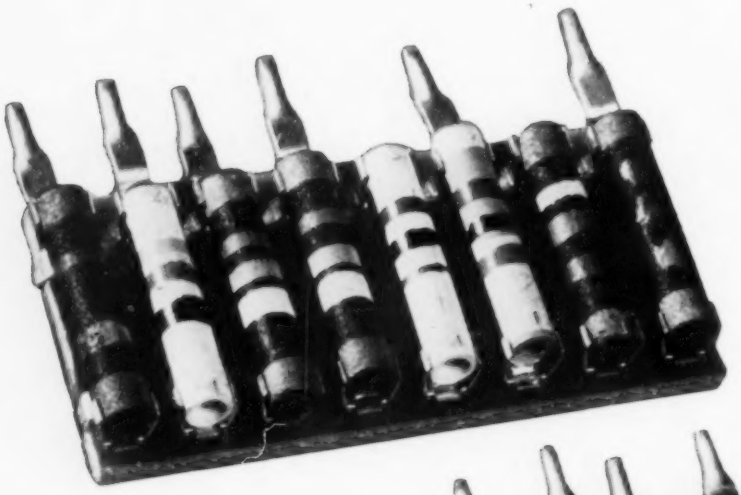
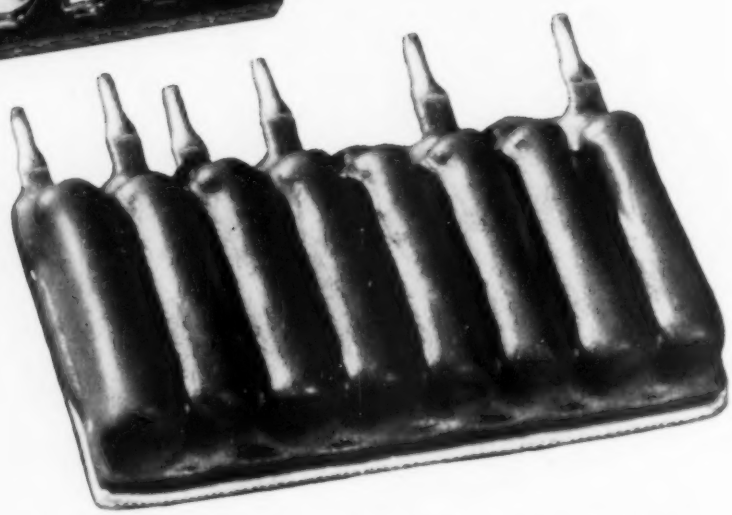
wrapping up a problem in electronics



Approx. 2½ times actual size



...Coatings for sub-assemblies suggest **other** jobs for **DUREZ** phenolic **RESINS**

IF YOU ARE FACED with a situation requiring exceptional properties in a bonding, impregnating, or coating agent, consider what Erie Resistor Corp. accomplished when it turned to Durez resins for its Pre-Assembled Components.

DEVELOPED TO EFFECT major cost reductions for electronic equipment manufacturers, these Erie "PAC" circuits combine capacitors and resistors in unitized packages for quick installation in a printed circuit board. Complete flexibility of design is offered in modules combining up to 90 components in one "package."

INSULATING PROPERTIES, mechanical strength, and heat resistance of Durez thermosetting phenolic are key factors in the protective dip-coating applied to "PAC" units. With Durez, Erie meets its own requirements that no migration or peel-back of insulating material occur when a soldering gun is applied. In the dip compound the resin produces a material that is free from running or sagging. The slight porosity of Durez allows Erie's protective wax coating to penetrate to a depth that insures complete insulation, and it cures to a hardness that permits stamping or color coding.

Can the remarkable properties of Durez thermosetting phenolic resins solve a problem for you? Whether thermal, electrical, or mechanical characteristics come first in the application you may have in mind, why not look into Durez now? Feel free to call on our long experience with these materials.

DUREZ®

Phenolic Plastics that Fit the Job

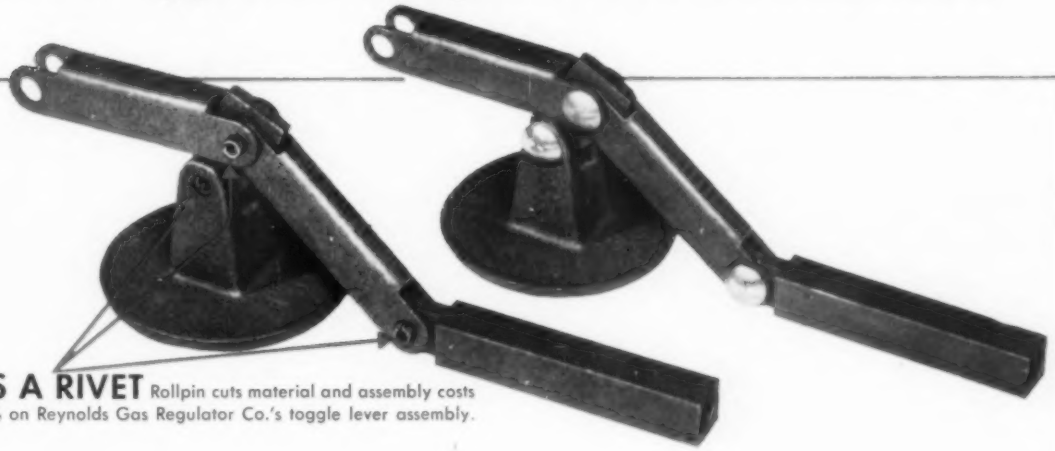
DUREZ PLASTICS DIVISION

HOOKER ELECTROCHEMICAL COMPANY

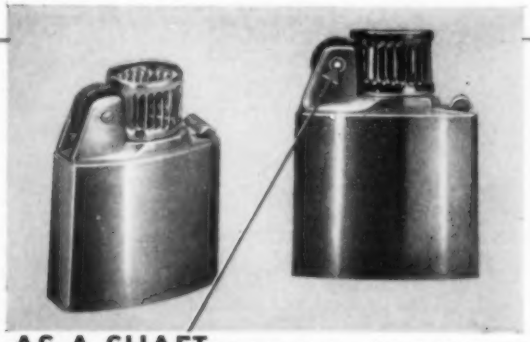
1508 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICALS PLASTICS

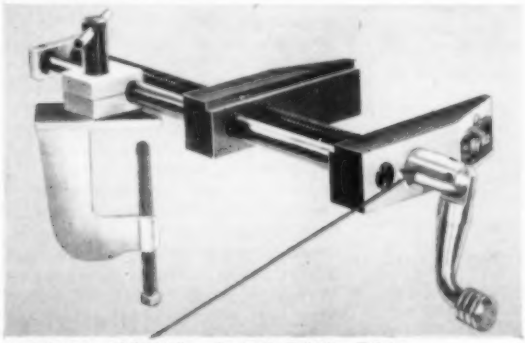
Three typical Rollpin cost reductions



AS A RIVET Rollpin cuts material and assembly costs 25% on Reynolds Gas Regulator Co.'s toggle lever assembly.



AS A SHAFT before and after shot of this Ronson lighter shows how Rollpin made savings of 1½¢ per unit in assembly of spark wheel.



REPLACING A TAPER PIN Rollpin saves 24¢ labor cost on each of American Machine and Foundry's MITY-7-VISES. Eliminates tool cost caused by breakage of small taper reamers.

ESNA TRADE MARK

ROLLPIN TRADEMARK

Where can you use this simple fastener?

If you use locating dowels, hinge pins, rivets, set screws—or straight, knurled, tapered or cotter type pins—Rollpin can cut your production and maintenance costs as it does in every class of industry. Rollpin is a slotted tubular steel pin with chamfered ends that drives easily into standard holes, compressing as driven. Its spring action locks it in place—withstanding impact loading, stress reversals and severe vibration. No threading, peening or precision drilling needed. Rollpin is readily removable and can be re-used in the same hole.

ELASTIC STOP NUT CORPORATION OF AMERICA

MAIL COUPON FOR DESIGN INFORMATION

Elastic Stop Nut Corporation of America
Dept. R38-82, 2330 Vauxhall Road, Union, N. J.

Please send the following fastener information:

☐ Rollpin samples

☐ Rollpin bulletin

☐ Here is a drawing of our product. What self-locking fastener would you suggest?

Name_____ Title_____

Firm_____

Street_____ Zone____ State_____

New trends and developments in designing electrical products...

- First radially heat-treated magnets ever mass-produced
- G-E thermistor makes new temperature controls more sensitive

G-E Magnet Engineers turn idea into reality

The physicist at Roanwell Corp., Brooklyn, New York, had the idea – but it took a revolutionary development in magnet manufacture to make it come true.

Roanwell was working on a new receiver for military headsets sensitive enough to distinguish sounds clearly, even under combat conditions.

A new, dynamic receiver design solved the sensitivity problem. But then the weight and height of the unit had to be reduced to make it less bulky in the aviator's helmet.

Original specifications called for an assembly of several magnets which was smaller than the plug-type magnet normally used. But the Roanwell physicist's idea was to use a *single* radially heat-treated Alnico 5 magnet to reduce the size still further, and eliminate extra fabrication steps.

No one had ever mass-produced a radially heat-treated magnet like this before (Fig. 1). And no one knew if it could be done. So Magnet Engineers from General Electric were called in to try.

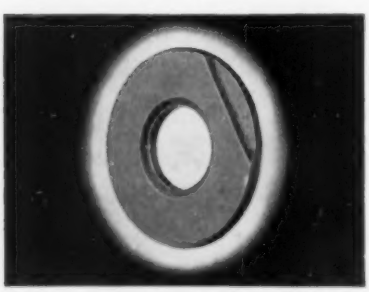


Figure 1

They solved the problem all right. But here's what they had to go through to do it:

First, they came up with special directionalizing equipment to orient the magnetic domains so the magnet could be magnetized radially.

Next, with engineers in G.E.'s unique Quality Standards Laboratory, they worked out the processing technology for mass production.

This meant starting from scratch to determine the initial heating temperature, rate of coiling, best field shape. It meant calculating axes of the directionalizing coil, computing proper aging time and temperature. And finally, it meant thorough testing and careful control of production.

The result: Roanwell is now using the first commercially produced radially heat-treated magnets (Fig. 2). The magnet produces the same flux density, but it requires less height (in fact, about half the height of a plug magnet).

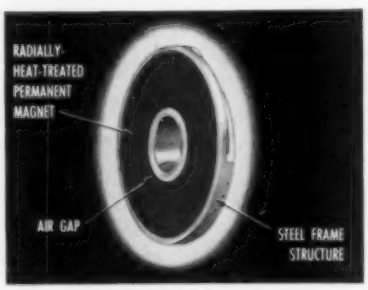


Figure 2

Because a single magnet is used, the unit is stronger, more reliable . . . and has the needed sensitivity. Equally important, the magnet can be machined accurately. This is critical because the circular air gap for the vibrating coil (see Fig. 2) is only a few thousandths wide, and magnet tolerances must be held as tightly as possible.

For Roanwell, G-E Magnet Engineers came up with this new method for mass-producing radially heat-treated magnets. For other manufacturers, they have handled jobs ranging from the design of complete magnetic circuits to development of new magnetizing and testing procedures.

Whatever the problem, G-E Magnet Engineers have the experience, skills, and the facilities behind them to solve it.

To get their expert design assistance, or your copy of the new G-E Magnet Design Manual, all you have to do is write: *Magnetic Materials Section, General Electric Company, 7812 N. Neff Street, Edmore, Mich.*

G-E thermistor gives new temperature control sensitivity to 0.075° F.

Furnace heat maintained at given levels, and alarms sounded when temperatures exceed specified limits – both can be controlled by a new device called the "Simplytrol."

The Simplytrol is made by Assembly Products, Inc., Chesterland, Ohio. It responds to changes as small as 0.075° F. because it uses a G-E thermistor as the sensing device.

The thermistor is one leg of a bridge in circuit with a D'Arsonval meter relay. (Fig. 3).

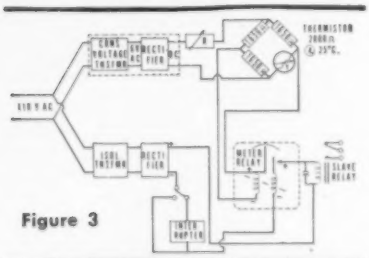


Figure 3

Because the thermistor has a large *negative* temperature coefficient of resistance, even minute changes unbalance the bridge to let the current actuate the relay.

The thermistor is more sensitive than other types of sensing elements. And in the Simplytrol, it can be wired up to 200 feet from the control without affecting accuracy.

In these and similar devices, the thermistor senses changes in ambient temperature. However, when it is heated by the current of the circuit, a whole new range of applications is opened: voltage regulators, time delays, sequence switching devices.

If you have problems in these application areas, experiment in your plant with G-E Thermistor Kits – they're only $12.50 each. To find out which is best suited to your needs, write: *Magnetic Materials Section, General Electric Company, 7812 N. Neff Street, Edmore, Michigan.*

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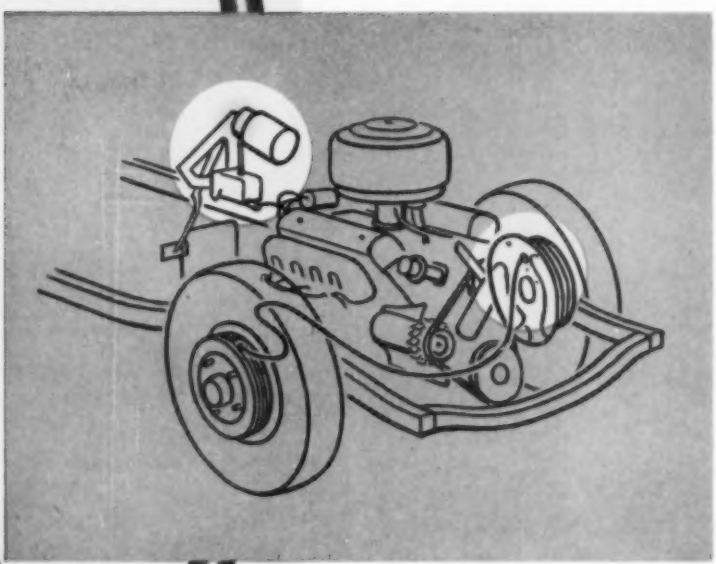
GENERAL ELECTRIC

...for greater safety...LONGER

LINEAR KEEPS THE POWER
IN POWER BRAKES
with Roto-Mold "O" Rings



Power brake systems, that stop two tons of automobile with pedal pressures too light to crack an egg shell, require lasting seals of uniform physicals and dimensions—seals that will withstand actuating fluid pressures . . . mechanical wear . . . abuse . . . chemical action of brake fluids and destructive action of improper hydraulic mediums.

LINEAR'S ability to produce precision "O" rings in the most modern elastomers has helped solve a wide variety of sealing problems involving extreme ranges of temperatures (from −130° to 450° F), operating pressures up to 50,000 psi, and the corrosive action of silicate or phosphate esters, hydrocarbon or petroleum base fluids, or synthetic lubricants.

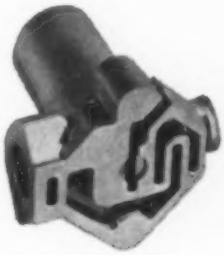
The exclusive Roto-Mold process assures top quality production . . . maximum economy . . . fast delivery schedules.

When it's a sealing problem, call on LINEAR or one of its agents for engineering assistance . . .
and be sure to specify LINEAR Roto-Mold "O" Rings.

"PERFECTION IN RUBBER"
LINEAR
LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA. 35, PA.

CHARACTERISTICS OF CENTRAL FOUNDRY SHELL CASTINGS THAT WIDEN THE LATITUDE OF **product design**

intricate designs which are not practical with sand-castings, can frequently be produced in volume by the CENTRAL FOUNDRY SHELL MOLD PROCESS. Deep pockets can be drawn with a minimum of pattern draft. Pieces can be cast which have grooves and recesses without the need of additional cores, and the relationship of holes to the body portion can be maintained. The governor body is an example of this characteristic of shell castings.



closer tolerances can be held with shell castings than with green sand castings. The transmission drum is a typical example of a piece that gained by being held to very close dimensions. This factor can affect product design by making it possible to take advantage of the strength of alloy grey iron or ArmaSteel in a piece that might otherwise have to be die-cast in a soft metal.

the better dimensional control of shell castings makes it possible to substantially alter the design of a piece. Narrow spaces between counterweights in a crankshaft, for example, can be produced that are impossible in a forging.

smoother surfaces • Shell casting permits excellent duplication of surface detail. The engineer designing a piece that should possess high strength, but also some detail as to surface (such as cast-in lettering) may now find the answer in a shell casting.

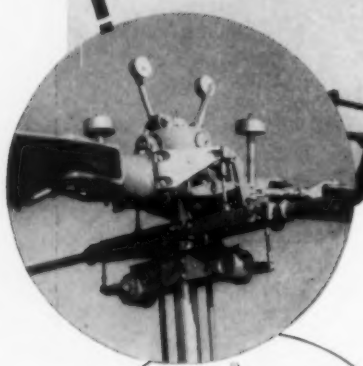
shell coring produces more accurate internal surfaces. Because shell cores are cured in the corebox, intricate shapes are possible.

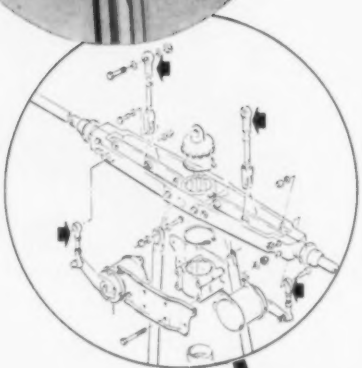
So many characteristics of CENTRAL FOUNDRY shell castings permit improvement in design, in material and in net cost that design engineers in many industries are specifically recommending these castings of grey iron, malleable iron or ArmaSteel. For further engineering data write for new 36-page shell casting manual . . . just completed.

74

CENTRAL FOUNDRY DIVISION

GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN • DEPT. 10





THE NEW "BELL RANGER" HELICOPTER USES HEIM UNIBAL ROD ENDS

Model 47-J is the latest helicopter to be introduced to the commercial market by Bell Helicopter Corp., and has been named the Bell Ranger. It is a four-place, executive type machine with a deluxe interior or a series of quick-change cabin arrangements for cargo, litter, and internal hoist configurations.

HEIM Unibal Rod Ends were chosen for the linkages in the carburetor heat and mixture control installations, and in the main rotor stabilizer bar assembly. The rods link hydraulic dampers to the bar, which provides exceptional stability to the flight characteristics of Bell helicopters, acting like a gyroscope and, through mixing levers, keeps the rotor plane of rotation in its pre-established flight path.

THE HEIM *Unibal* is the spherical bearing which corrects misalignment in every direction because of the universal movement of the ball — Reduces friction and lost motion in linkages — Eliminates the effects of vibration — Lowers assembly costs because of its quick and easy installation — Carries heavier loads.

Perhaps Heim can help solve — or simplify — your linkage problems. Feel free to write. Be sure each engineering and purchasing department has a Heim catalog.

THE HEIM COMPANY / Fairfield, Connecticut

Standing ready to serve you!

Your local steel distributor plays a vital role in your production picture. He supplies that all-important material–steel–in any amount, size, or shape, from his well-stocked warehouse. And he delivers immediately upon demand!

Whether you need a small quantity of steel to wind up a job without going back to the mill–or a medium-size quantity to supplement your present supply–your distributor is capable and instantly ready to fill any need. He's truly "at home" with your problem, regardless of its size.

Your local warehouse distributor is indeed the strongest link between the mill and you–an indispensable supply source. And he's never any farther away than your telephone.

Call him for any quantity of Weirkote zinc-coated sheets–Weirzin electrolytic zinc-coated sheets–or hot or cold rolled sheets. You'll be surprised at the scope of the services he offers you . . . courteously and punctually.

WEIRTON STEEL COMPANY

WEIRTON STEEL COMPANY

WEIRTON, WEST VIRGINIA

a division of

NATIONAL STEEL CORPORATION

Note—Commercial and Military Packaging Engineers:

LINK-LOCK

...is the rugged answer to your exacting container closure problems

LINK-LOCK plays an important role in the design of this container

Simmons' LINK-LOCK provides pressure-tight, impact-resistant closure, plus quick closing and opening, on this reinforced fibrous plastic product made by the new automatic pre-form process developed by Pressurform Container Corp. The two-section container will be used by the Light Military Electronic Equipment Dept. of General Electric Company for shipping airborne radar jamming units to the Air Force.

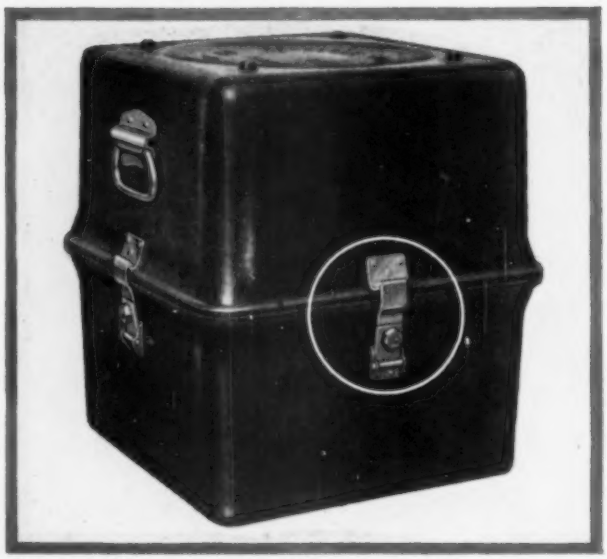
Of prime importance are the container's lightness, strength, rust- and mildew-resistance, ability to withstand high pressures without distortion, ease of locking and opening, and low cost.

Here's why LINK-LOCK is ideal for use on military cases produced to exacting specifications as well as on inexpensive commercial containers:

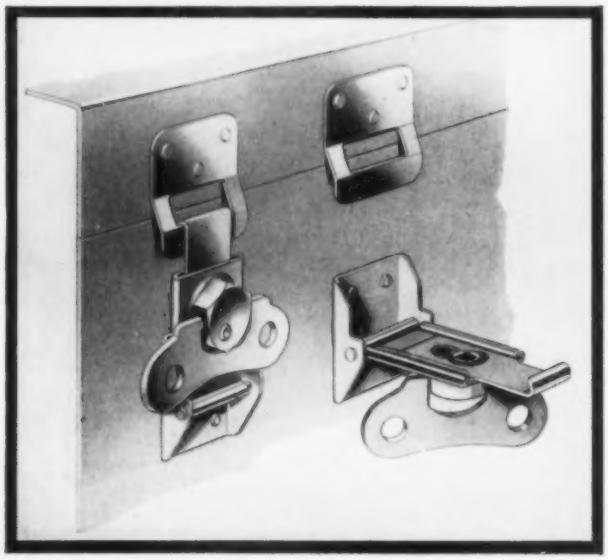
- High closing pressure with light operating torque... insures pressure-tight seals where required.
- Impact and shock resistant (positive-locking).
- Compact design... lays flat against case even when unlocked.
- Available in 3 sizes, for heavy, medium, and light duty.
- Opening and closing by wing-nut, screwhead, or hex nut.
- Flexible engagement latch design... can be varied to suit different conditions.

Also available! Spring-Loaded LINK-LOCK... ideal for less expensive containers where costs won't permit precision production. Spring provides take-up to compensate for set in gasketing, irregularities of sealing surfaces, and mounting inaccuracies.

Where does the versatile Simmons LINK-LOCK belong in your design? For full information and specifications, send for LINK-LOCK DATA SHEETS today. Samples and engineering service available upon request.



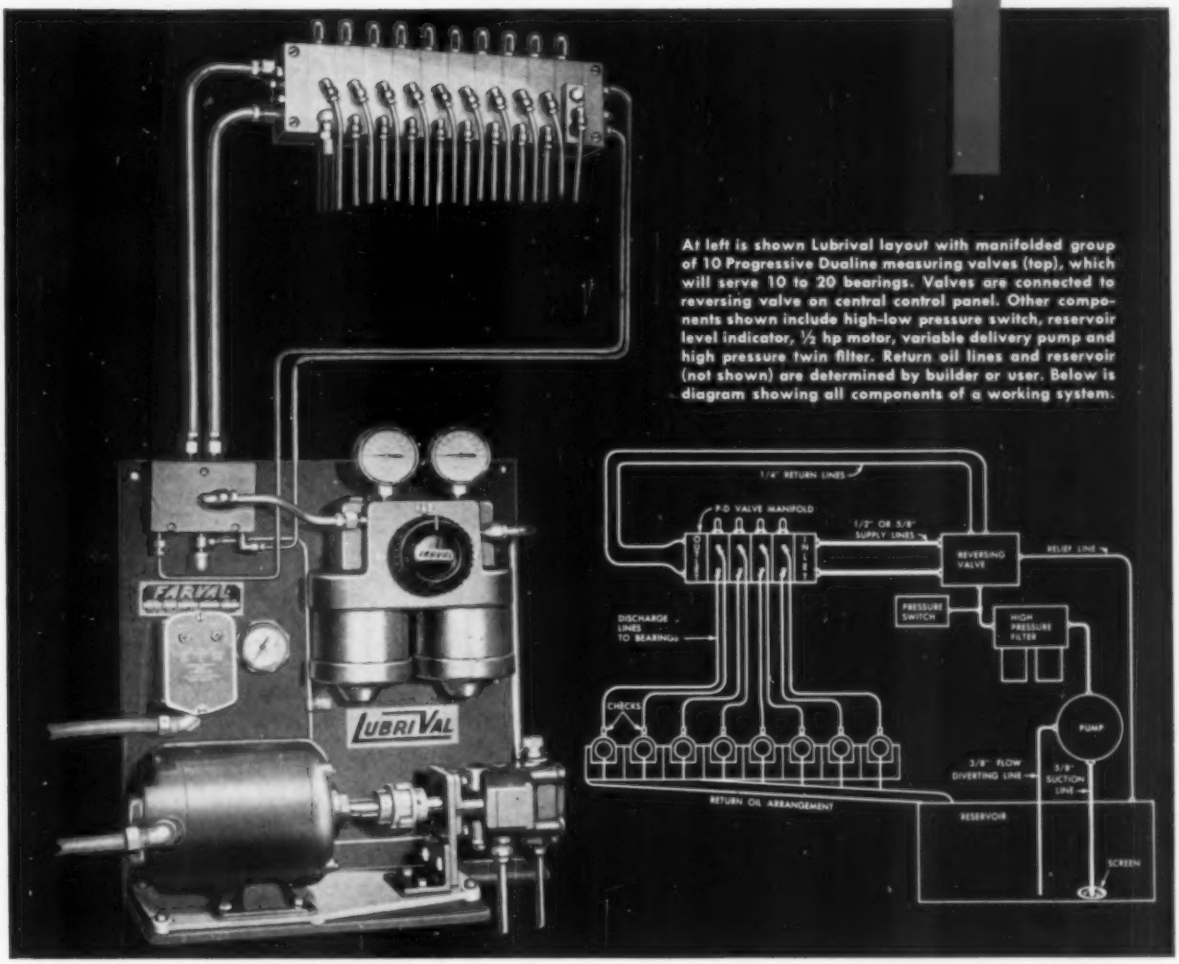
Courtesy of Pressurform Container Corp., and the LMEE Dept. of General Electric Co.



SIMMONS
FASTENER CORPORATION
1751 North Broadway, Albany 1, New York
QUICK-LOCK SPRING-LOCK ROTO-LOCK LINK-LOCK DUAL-LOCK

LUBRIVAL —a revolutionary new system to supply and circulate lubricating oil

FARVAL—
Studies in Centralized Lubrication
No. 204



At left is shown Lubrival layout with manifolded group of 10 Progressive Dualine measuring valves (top), which will serve 10 to 20 bearings. Valves are connected to reversing valve on central control panel. Other components shown include high-low pressure switch, reservoir level indicator, ½ hp motor, variable delivery pump and high pressure twin filter. Return oil lines and reservoir (not shown) are determined by builder or user. Below is diagram showing all components of a working system.

● Lubrival is designed for low volume, high pressure circulating lubrication of presses, automatic and semi-automatic machine tools and other industrial equipment designed for circulating oil systems.

Lubrival is a Farval system, employing the Dualine principle of delivering oil to measuring valves which pass it under pressure to bearings. Lubricant is force-fed by positive piston displacement. Flow can be regulated over a range of 10 ounces to 1 gallon per minute.

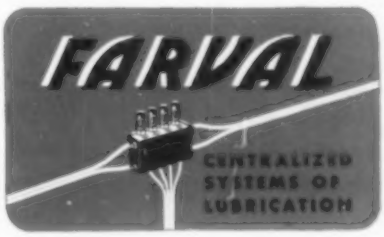
Lubrival Progressive Dualine Valves, manifolded in any number required, have individual sight indicators. A pressure sensing mechanism warns of clogged or broken lines in *any part* of the system—a feature entirely new to circulating oil systems.

For dependable protection of bearings and economical operation of machines, look into Lubrival. If you are a builder, offer Lubrival protection to your customers. If you use presses and machine tools, specify Lubrival on your next equipment order. The Farval representative near you will give you all details. Or write for Bulletin 70. The Farval Corporation, 3279 East 80th Street, Cleveland 4, Ohio.

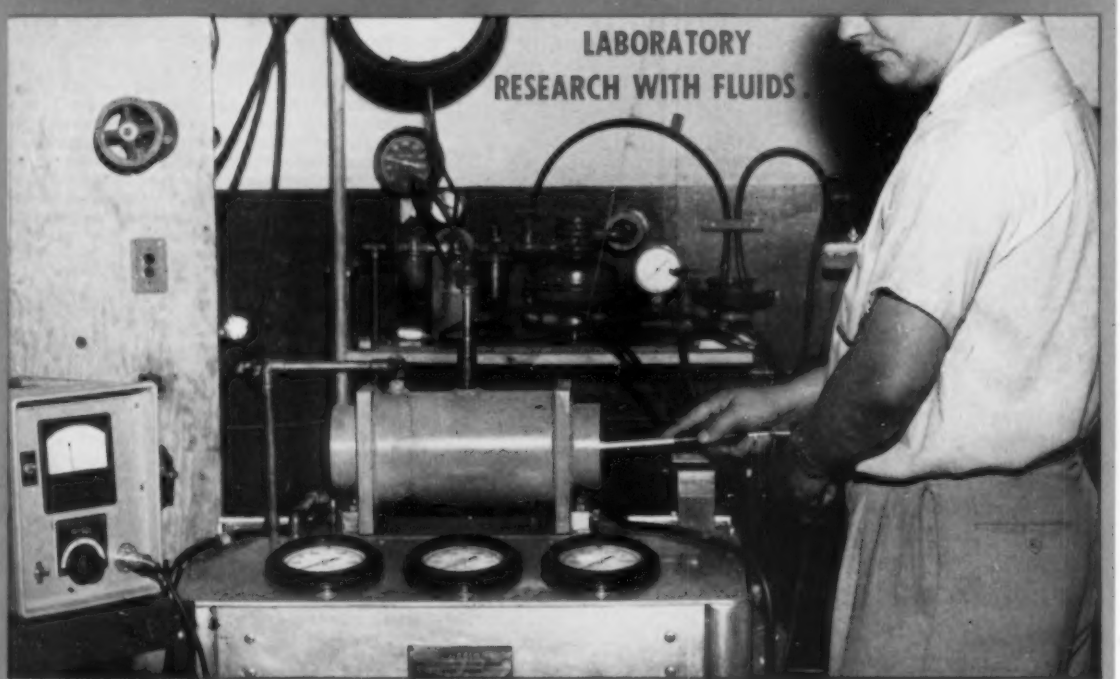
Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.

KEYS TO ADEQUATE LUBRICATION—

Wherever you see the familiar Dualine valve manifolds, dual lubricant lines and central pumping station, you know a machine is being properly lubricated. Farval manually operated and automatic systems protect millions of industrial bearings.



Complete Line of



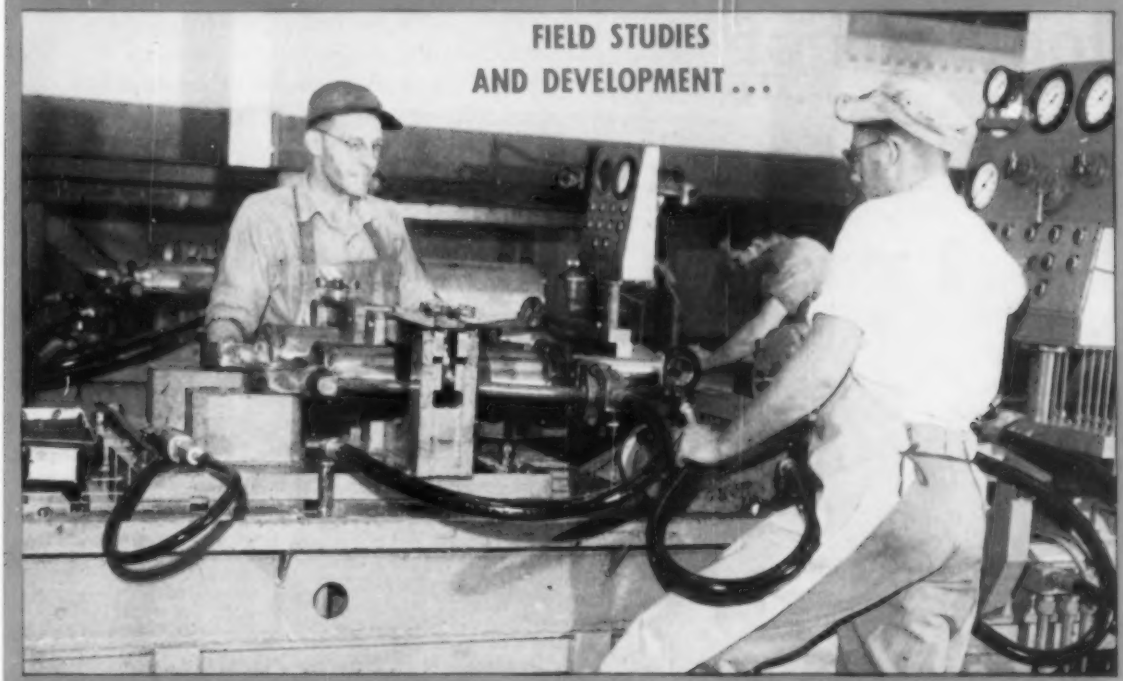
HOUGHTON'S Background in Packings &

Years of hydraulic experience have earned for Houghton a position of leadership in both packings and fluids on which you are invited to cash in.

From this one source, you can get a complete range of sizes in cups, "V's", "U's" and "O" rings in wax impregnated leather, rubber impregnated leather, fabricated rubber and homogeneous rubber. In the field of packings, Houghton's know-how is proven by their leadership in standardization; in unique standard stack height for rubber, fabricated and leather "V's"; in the development of the only thoroughly rubber impregnated leather packings; and the advanced "square shoulder and flare" design of cup packings.

Houghton can also give you the advantages of its leadership in hydraulic fluids. In this field, Houghton was the first to develop a petroleum hydraulic oil specifically fortified to meet the

Types and Materials...



Fluids means Better Hydraulic Products

requirements of hydraulic operation; Houghton pioneered in the development of fire-resistant hydraulic fluids—equipping every U.S. aircraft carrier with fire-resistant Houghto-Safe.

Don't fail to take advantage of Houghton's background in packings and fluids for your application.

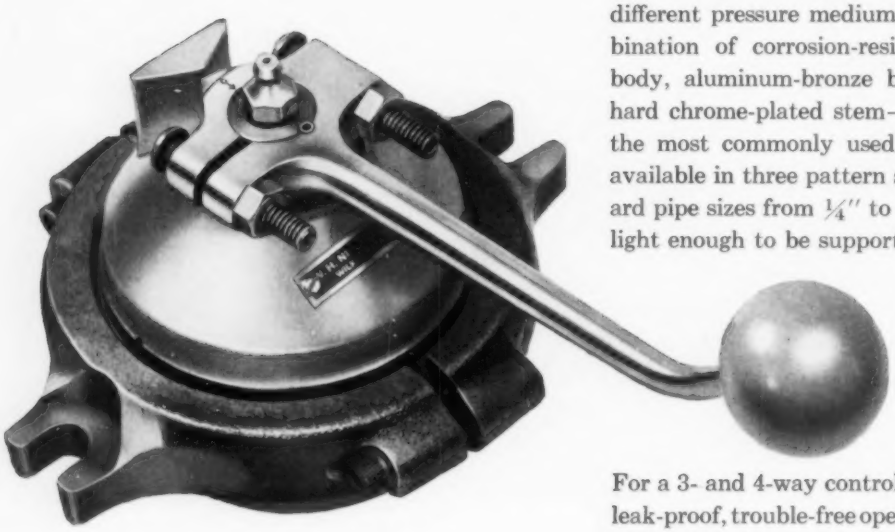
products of...

E. F. HOUGHTON & CO.
PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service . . .

Here's a control valve that assures you

leak-proof service



Highly-lapped metal-to-metal surfaces of this Nicholson control valve assure you leak-proof service. The O-ring stem packing and O-ring seal between the body and base make joints leak-proof without excessive bolt tension.

You can use the Model 300 with air, water, hydraulic fluid or oil as the pressure medium . . . at operating pressures to 300 psi. Use it to activate single- or double-acting cylinders. Simple and rugged, this valve provides accurate, repeatable control of equipment such as presses, hoists, clutches and chucks. Valve maintenance is no problem . . . all stem, base and disc bearing surfaces are lubricated through one easily accessible fitting on top of valve stem. Lubricant reservoir in base reduces frequency of lubrication.

No need to stock valves or parts for service with different pressure mediums. This valve's *one* combination of corrosion-resistant materials—bronze body, aluminum-bronze base, stainless-steel disc, hard chrome-plated stem—is well suited for all of the most commonly used pressure mediums. It's available in three pattern sizes covering five standard pipe sizes from ¼″ to 1″ . . . small enough and light enough to be supported by connected piping.

For a 3- and 4-way control valve that will give you leak-proof, trouble-free operation, specify Nicholson. W. H. NICHOLSON AND COMPANY, 14 OREGON ST., WILKES-BARRE, PA. Sales and Engineering Offices in 98 principal cities.

Write for Bulletin 300 . . . covering design, construction, sizes and applications for the Model 300

NICHOLSON

OF WILKES-BARRE

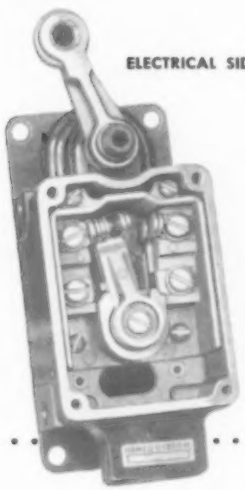
PROVED . . . by millions of contacts

NATIONAL ACME
SNAP-LOCK
TRADE MARK

As illustrated below, National Acme SNAP-LOCK Limit Switches employ a basically simple yet positive *snap-action* locking mechanism—with extremely few moving parts. Thus wear is reduced to a minimum and dependable trouble-free service, far beyond normal limits, is assured.

The double-throw contact lever, connected directly by shaft with the latch bar, carries self-wiping coin silver contact points to assure quick action make or break—reducing wear ever further.

Electrical and mechanical sides are separated by a wall within a sturdy die-cast housing which is fully insulated and is dust and oil-tight.



THE ORIGINAL
SNAP-ACTION LOCKING SWITCH

SNAP-LOCK LIMIT SWITCHES. Made in single-pole and double-pole series, in four types: Standard, Short Travel, Neutral Position and Push Lever. With the exception of the Push Lever Switch, all are adaptable to special enclosures for hazardous location service and may be used with various styles of operating levers. For AC or DC service.

and now . . .

a new design concept for **CONTROL STATION SWITCHES**
the heavy-duty . . . oil, water, dust tight **GOLD-N-RING**
made by machine tool builders to machine tool specifications

Heavy duty silver-alloy contact points provide maximum electrical capacity, long life.
Heavy duty terminal screws have ⅜" thread contact to prevent stripping during installation and permanently secure wires for continuous, trouble-free service.
Single or double-pole contact block assemblies—can be used interchangeably with several types of GOLD-N-RING push button and selector operator heads.
Rated for 600 volts—AC or DC. Meets all Joint Industry Committee and National Machine Tool Builder's Association requirements.
Protected against oil and water seepage in operator head by Sealtight oil-resistant rubber diaphragm.
Easily replaces existing switches.

ELECTRICAL MANUFACTURING DIVISION

the National Acme company

170 EAST 131st STREET, CLEVELAND 8, OHIO

Good Delivery on Electroplated Fasteners

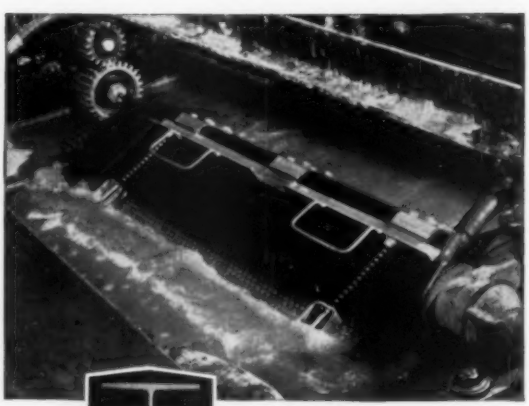
Any time your products call for electroplated fasteners —either bright-zinc-plated or cadmium-plated—get in touch with Bethlehem.

Bethlehem electroplated fasteners have a smooth, good looking finish. They meet ASTM Specifications A 164-55 RS, LS and GS, and can be produced quickly in practically any size up to a maximum length of 30 in.

We'll be pleased to furnish complete information about electroplated fasteners, whether you need a handful or a carload. Just get in touch with the nearest Bethlehem office, or write to us at Bethlehem, Pa.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

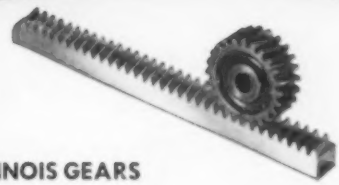
On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation



Bethlehem has complete facilities for volume production of electroplated fasteners. Inset shows the plating barrel in the coating solution.

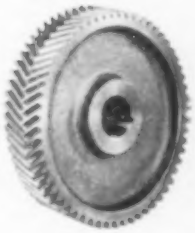
BETHLEHEM STEEL

Wherever Power is on the move . . .



INDUSTRY DEPENDS ON ILLINOIS GEAR

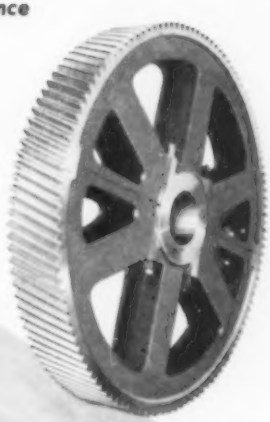
Throughout the world . . . wherever power is on the move . . . ILLINOIS GEARS are *delivering this power* dependably year in and year out.

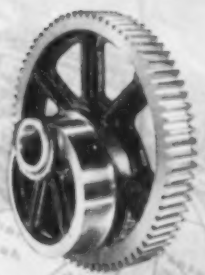


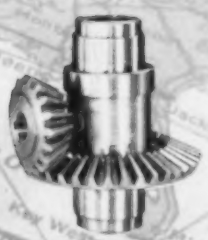
Whether it is in machine tools, steel mills, cement mills, paper mills, chemical plants, construction equipment . . . machinery of any kind . . . this dependability, proven by performance, means true economy that has resulted in enduring customer satisfaction.

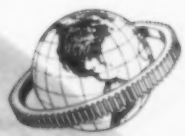
When you need gears—remember this: ILLINOIS GEAR manufactures *the most complete line of quality gears in the world.*

You can specify and buy ILLINOIS GEARS *with confidence and assurance* that they will more than satisfy your most exacting requirements.









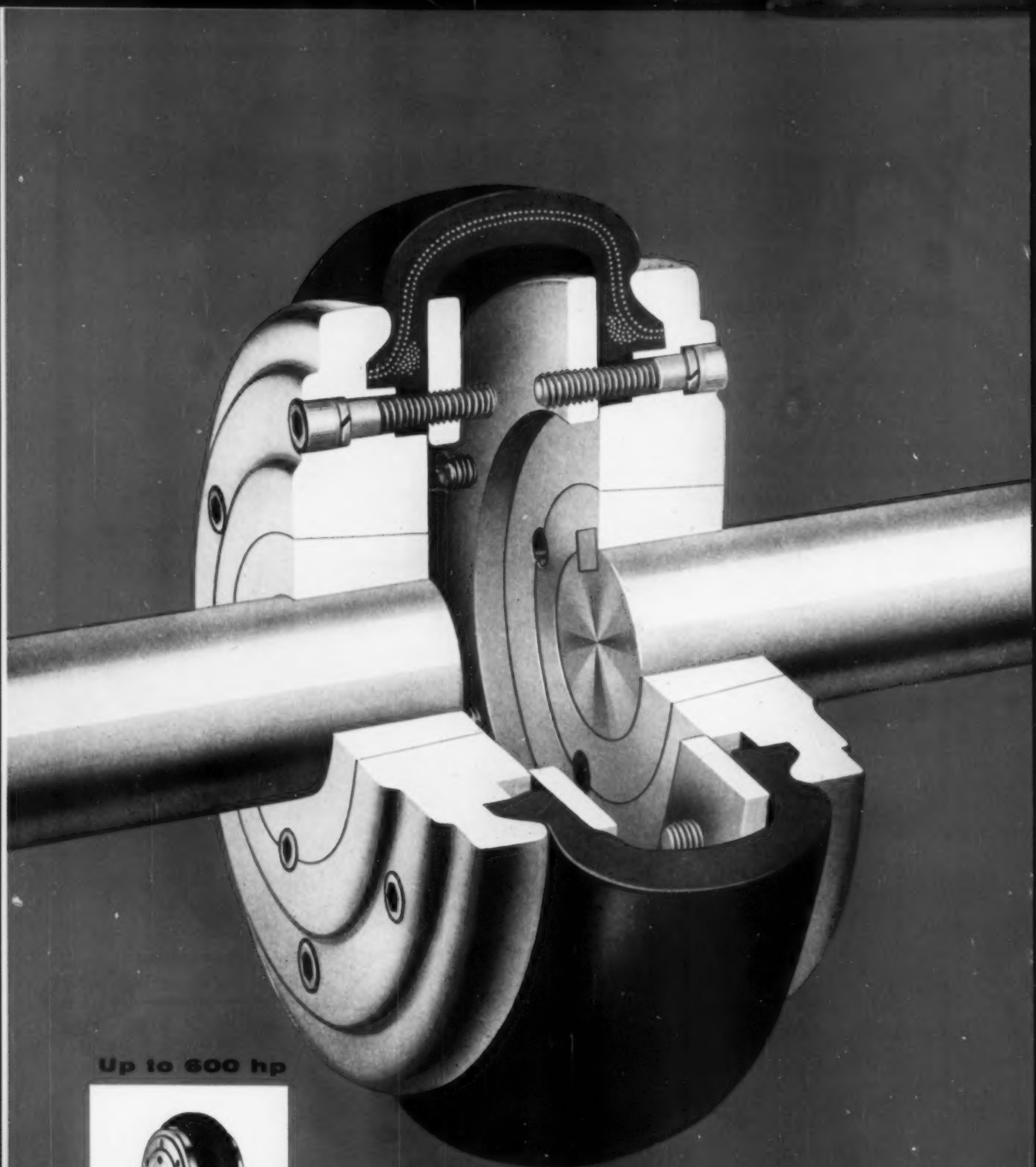
Look for this mark ILG® *the symbol on finer gears*

ILLINOIS GEARS Reg. U.S. Pat. Off.

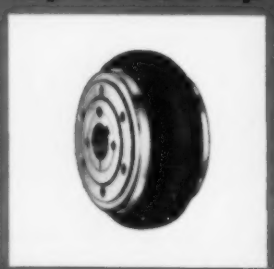
Gears for Every Purpose ... one gear or 10,000 or more

ILLINOIS GEAR & MACHINE COMPANY

2108 NORTH NATCHEZ AVENUE CHICAGO 35, ILLINOIS



Up to 600 hp



NOW! THE COUPLING WITH THE 4-WAY FLEX!

Para·flex

FLEXIBLE CUSHION COUPLING

THE NEW IDEA IN FLEXIBLE COUPLINGS... WITH A FLEXING BODY THAT AUTOMATICALLY COMPENSATES FOR ALL COMBINATIONS OF MISALIGNMENT AND END FLOAT... AND CUSHIONS SHOCK LOADS!

THIS Coupling "swallows up" misalignment! Its ability to handle multiple displacement is exceeded only in a universal joint. It outperforms the most complex coupling mechanisms—yet it operates with the simplicity—*and the dependability*—of a modern tire!

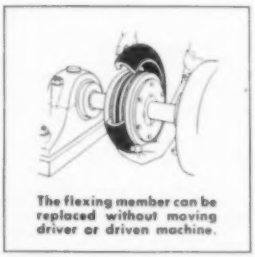
The technological advances that contribute to the miracle of today's truck tires, which are engineered to carry tremendous loads at high speeds and stand terrific shock, have made this new type of coupling possible.

The heart of Para-flex is a tire with synthetic tension members bonded together in rubber. It is pliant. It "fits itself" to changing shaft conditions—angular, parallel, end-float, *or any combination of all three!* Depending upon the size of coupling and duration of shaft misplacement, it handles angular misalignment up to 4°, parallel up to ⅛" and end-float up to 5/16".

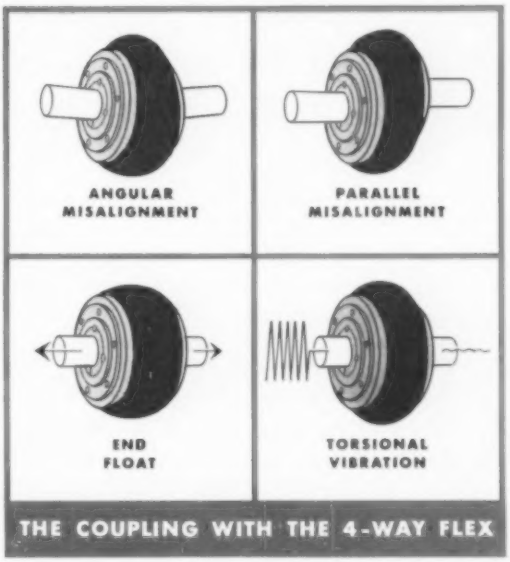
It cushions the stresses of shock loads to a remarkable degree. And it tends to absorb torsional vibration—reducing noise and protecting machinery from vibration's destructive forces.

There is no metal-to-metal contact between shafts. They are insulated. No lubrication is required.

Para-flex takes a minimum of space on the shaft. Mounting is simplified through the use of standard Taper-Lock bushings — no reboring, no machining. Safety is promoted by flush design; there are no protruding parts. And since the flexible member is molded with a transverse split, it can be replaced *without moving either the driver or driven machine!*



The flexing member can be replaced without moving driver or driven machine.



THE COUPLING WITH THE 4-WAY FLEX

Para-flex Couplings are stocked by Dodge Distributors in popular transmission sizes. They are available from factory stock in capacities up to 600 hp at 900 rpm. Call your distributor for early delivery to *make your own test.* You'll witness something revolutionary!

DODGE MANUFACTURING CORPORATION, 1200 Union Street, Mishawaka, Indiana

DODGE

of Mishawaka, Ind.

CALL THE TRANSMISSIONEER, your local Dodge Distributor. Factory trained by Dodge, he can give you valuable assistance on new methods. Look for his name under "Power Transmission Machinery" in the yellow pages of your classified telephone directory—or write us.

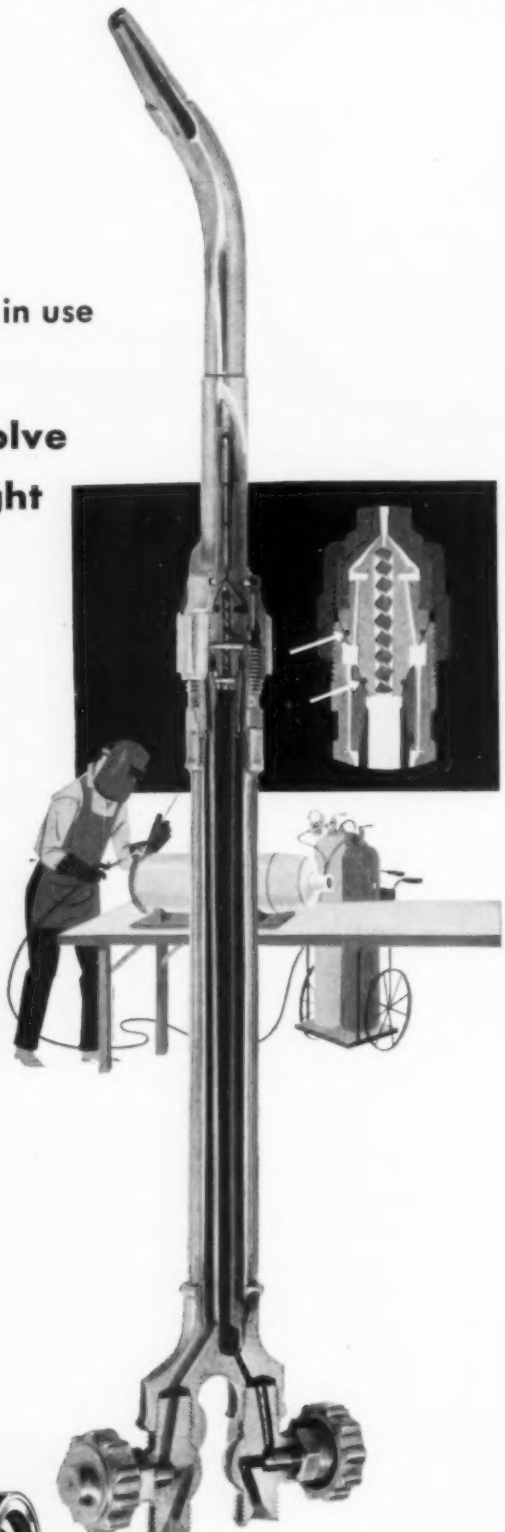
Ozone deterioration

Continuing stress

Gas leakage

Rough handling in use

New National Hypalon O-rings solve these problems; insure a hand-tight gas seal in Victor Torches



As static seals, commercial Buna N O-rings performed satisfactorily in Victor welding torches — *when the rings were new.*

However, ordinary O-rings age fast in welding torches. They receive rough treatment when welders change nozzles; nozzles are often dropped on the ground to lie there until needed again. Severe ozone deterioration is experienced. Continuing stress, although mild, impairs O-ring elasticity. Rings on welding nozzles are sometimes subjected to long shelf life.

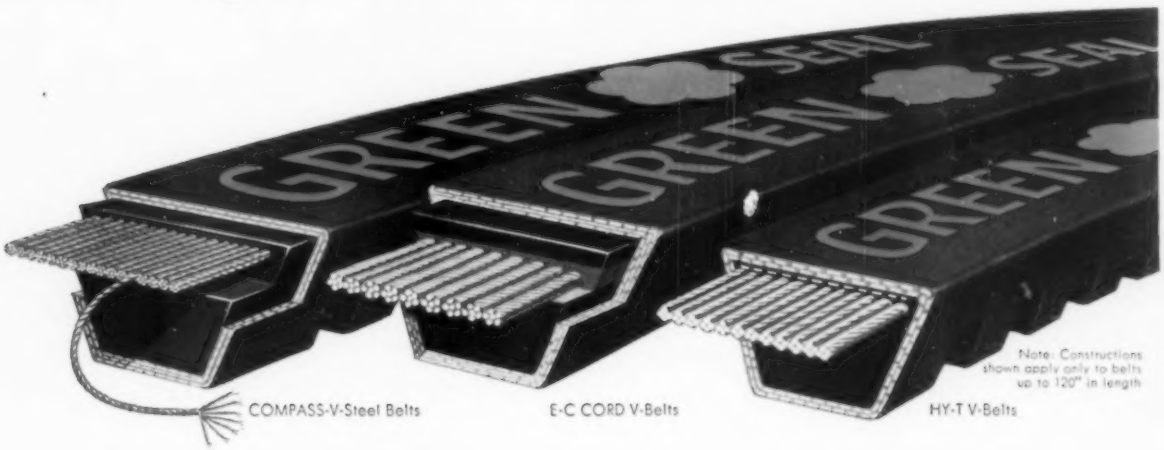
National Seal engineers developed a new O-ring compound, National Hypalon L-11, which not only withstands rough handling, ozone deterioration and stress but exhibits many times the shelf life of Buna N compounds previously used. Today, National Hypalon is standard at Victor.

Special compounding to meet unusual conditions is a basic part of National's complete O-ring engineering service — service available from National Field Engineers in major cities nationwide.

NATIONAL SEAL
Division, Federal-Mogul-Bower Bearings, Inc.
General Offices: Redwood City, California
Plants: Van Wert, Ohio, Redwood City and Downey, California

4374

Now—V-Belts with the Green Seal solve the major multiple drive problem



COMPASS-V-Steel Belts E-C CORD V-Belts HY-T V-Belts

Note: Constructions shown apply only to belts up to 120" in length

The Green Seal stands for true dimensional stability in V-belts. And with Green Seal dimensionally stable belts you can be sure that matched sets are truly matched and will stay matched—that mismatching (the biggest problem in belting multiple drives successfully) is a thing of the past.

The key to dimensional stability lies in the tension members of the belt. For many years, steel cables as developed by Goodyear were the only length stable load carriers, but now they have been joined by synthetic cords, thanks to the amazing Triple-Tempered 3-T process.

The 3-T process is an exclusive method of tempering the cord with Tension, Temperature and Time for maximum strength and minimum change in dimensions. This assures no change in length during storage plus greatly increased shock- and stretch-resistance on the drive.

The end result is smoother, longer-running teams of belts that give you maximum, trouble-free, horsepower hours at minimum cost. What better reason for specifying V-belts with the Green Seal?

DIMENSIONALLY STABLE V-BELTS with the GREEN SEAL by

GOODYEAR

THE GREATEST NAME IN RUBBER

The Goodyear Tire & Rubber Company, Industrial Products Division, Dept. 794, Akron 16, Ohio

Please send me more information about how V-Belts with the Green Seal solve the major problem in belting multiple V-belt drives.

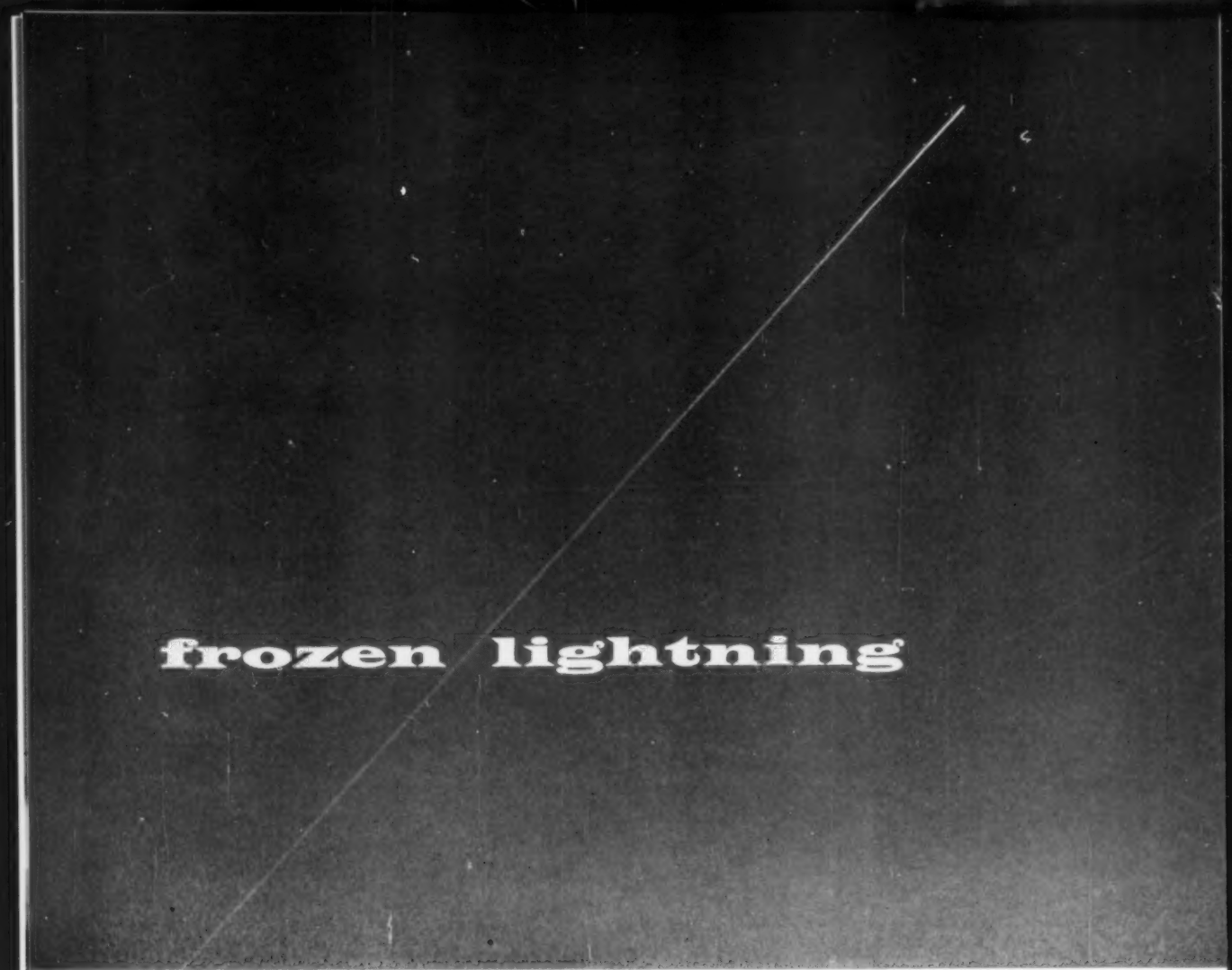
Name_____

Company_____

Street Address_____

City_____ Zone_____ State_____

Compass, E-C Cord, Hy-T, Green Seal—T. M.'s The Goodyear Tire & Rubber Company, Akron, Ohio



The Germans called the upper-atmosphere trails of their V-2 rockets "frozen lightning". When the Mach 4-5 aircraft now under development fly at 80-90,000 feet and higher, we'll be seeing frozen lightning in our own skies.

Not freezing but heating will be the *real* problem at these ultra high speeds. At 3000 mph, the skin and many structural components will be heated to over 1000°F, temperatures too high for alloys now used. Needed: materials strong up to 1200-1300°F for structural forgings and other stressed parts.

Engine builders, fastener manufacturers and forge shops are handling similar requirements right now, with Carpenter alloys. These alloys have gained an enviable reputation for uniform high quality, ability to meet tough specifications consistently, improved forgeability and exceptional cleanness. Forging tolerances can be tighter. Finishes are better. Rejects are far fewer.

Design properties and fabrication instructions for these alloys are summarized in our new booklet, "Carpenter Alloys for Elevated Temperature Service". For your copy drop us a line on your Company letterhead. The Carpenter Steel Company, 117 W. Bern Street, Reading, Pa.

Carpenter STEEL

Improved alloys for elevated temperature service

DOW CORNING CORPORATION

Silicone News

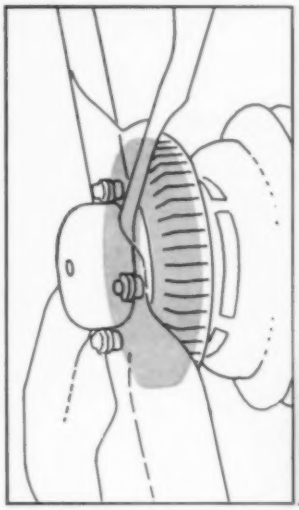
FOR DESIGN ENGINEERS No. 41

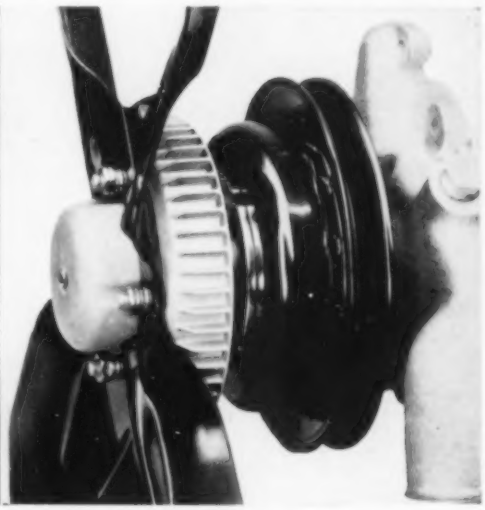
NEW SILICONE INSULATING RESINS FLOW FREELY WITHOUT SOLVENTS

Two new free-flowing, solventless silicone electrical resins are now available from Dow Corning in commercial quantities. Identified as R-7501 and R-7521, these 100% silicone resins are ideal for impregnating or encapsulating miniature and subminiature motors, transformers and other electrical and electronic assemblies.

Since both new resins pour freely, they quickly saturate and fill all voids in even the most complex assemblies, thus eliminating the problem of insulation punctures caused by escaping solvent gases. As shown in the photo, Dow Corning R-7521 is more fluid at room temperature and penetrates much deeper into 20-40 mesh sand than a conventional epoxy resin.

Both of the new resins cure to a strong, bubble-free mass having excellent dielectric properties, good thermal conductivity and high moisture resistance. When cured, they readily withstand continuous service at 400 F ambients and intermittent exposure to temperatures up to 500 F. (Cont. Pg. 2)





NEW MERCURY GETS "POWER BOOST" WITH THE HELP OF SILICONE FLUIDS

A thermostatically controlled hydraulic coupling on the engine fan is effecting a "Power Boost" of up to 17 hp on the 1957 Mercury automobile. It does so simply by basing the speed of the fan on engine coolant temperature rather than engine speed.

Identified as a "Thermo-Modulated Drive" by its manufacturer, the Schwitzer Corporation of Indianapolis, the unit was designed in conjunction with Mercury's Engine Engineering Office.

The coupling is made up of two mating faces separated by Dow Corning 200 Fluid. At coolant temperatures below 160 F, the distance between faces plus the viscosity of the fluid combine to keep the fan speed down to less than a quiet 1500 rpm.

Should engine temperatures approach the 190-200 F range, however, thermostatic control brings the coupling faces closer, the fluid achieves better traction and the fan picks up speed. But at 2600 rpm or so, fan speed again becomes constant.

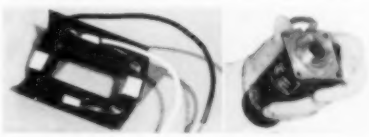
As a result, fan horsepower requirements are held to a minimum and fan noise is all but entirely eliminated. Figure 1 on the next page illustrates the fan-to-engine speed ratios and the horsepower savings offered by the Schwitzer "Modulated Drive".

Schwitzer has also developed a straight "Modulated Drive" coupling without the thermostatic control feature. This unit is being used by several automobile manufacturers in connection with their air-conditioned models, in which the cooling and power requirements of the engine and the air conditioner may be effectively balanced against each other. (Cont. Pg. 2)

Silicone Glass Coil Insulators Reduce Motor Assembly Costs

By insulating the coils of their ⅓ hp, 14,000 rpm afterburner ignition actuator motors with silicone-glass laminates, Lear, Inc., have cut costs a substantial $1.50 per unit.

Located next to jet engines where ambient temperatures soar to 400 F and higher, these motors have always been silicone protected. Lear originally tape-wrapped the coils by hand, but they recently eliminated this time-consuming job by switching to pre-formed glass laminates bonded with a Dow Corning silicone resin.

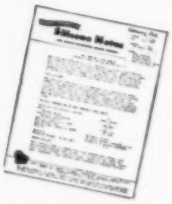


By reducing assembly time to an absolute minimum, the laminated insulators save Lear $1.50 per motor while still providing the maximum in insulating efficiency. The coil insulators are pre-formed in two sections by Stevens Products of East Orange, New Jersey. **No. 416**

DOW CORNING CORPORATION

Silicone News

DOW CORNING PUBLICATIONS ON NEW DEVELOPMENTS AND TECHNICAL DATA . . . .



Documentary film "What's a Silicone?" available free of charge for showings to technical audiences in every industry. In full color and sound, this dramatic 16 mm film allows you to see Dow Corning Silicones in action improving the performance of products ranging from nursing bottle nipples to diesel locomotives. For more information about this educational film and how to arrange a showing for interested persons in your plant, circle ---------- *No. 420*

"Effects of Radiation on Organopolysiloxanes," a research paper reprinted from Industrial and Engineering Chemistry, describes the effects of secondary radiation from 4 different sources on organopolysiloxanes. Sources include cyclotron radiation, cobalt — 60 gamma, electron, and X-ray. Results indicate that siloxanes containing large amounts of phenyl substitutions may be good construction materials around high energy radiation units. *No. 421*

Two new low-shrink silicone rubbers, Silastic 2067 and 2068 can be fabricated in molds designed for organic rubbers. Both have low compression set and good strength; are serviceable from —70 to +500 F. For data sheets on each, circle ---------- *No. 422*

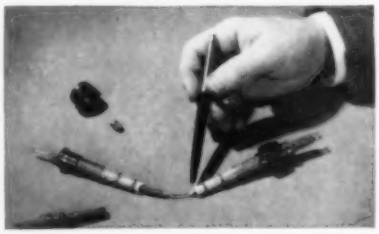
"What's a Silicone?" is the title of a 32-page booklet which answers that often asked question in semi-technical terms. Indexed and illustrated, this booklet has earned an international reputation as the most interesting and informative description of silicones ever published. *No. 423*

Dow Corning 41 Grease, for equipment operating at temperatures from zero to over 500 F, is described in a recently published brochure. Included are properties, typical applications, and case histories illustrating the practicality of 41 Grease in many different industrial applications. *No. 424*

Silastic — in mechanical applications — increases life and serviceability of original equipment; reduces maintenance and downtime. A completely new brochure gives properties and cites applications and case histories to help you use this versatile silicone rubber to best advantage in your application. *No. 425*

SILASTIC WITHSTANDS HIGH TEMPERATURE, HIGH VOLTAGE ON SPARK PLUG LEAD ASSEMBLY

Selecting a rubbery insulating material that would withstand up to 15,000 volts at 400 F in aircraft spark plug lead assemblies posed no problem for design engineers at Scintilla Division, Bendix Aviation Corporation, Sidney, New York. Already familiar with Silastic*, the Dow Corning silicone rubber, they knew it has excellent resistance to moisture and retains good mechanical and dielectric properties even after prolonged exposure to heat and high voltages.



Actually, Scintilla uses Silastic in four different areas on the new Bendix lead: for the inner and outer layers of the cable; for the molded terminal insulators; and as an interlayer to separate the three courses of braided metal sheathing. Interlaying the braided sheathing with Silastic not only keeps moisture out, but protects the sheathing against vibration to give it longer life.

The new Silastic insulated lead is now standard for the Wright turbo compound 18 cylinder, 3350 hp engine that powers the DC 7, the Super Constellation and various military aircraft. *No. 417*

*T. M. REG. U. S. PAT. OFF.

SILICONE FLUIDS *(continued)*

Reliability of Schwitzer couplings is assured by the use of Dow Corning 200 Fluid as the driving member. Conventional organic oils would thin out with increased temperature and become too viscous in cold weather, completely changing the characteristics of the coupling from those required. On the other hand, Dow Corning 200 Fluid retains a near constant viscosity over broad temperature spans and also eliminates maintenance problems. In tests, this silicone fluid shows no sign of gumming, sludging, or varnish after the equivalent of an estimated 100,000 miles on the road. *No. 418*

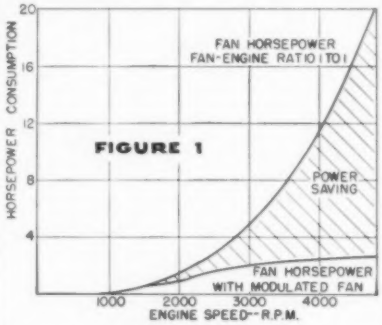


FIGURE 1

NEW SILICONE RESINS *(continued)*

At room temperature the viscosity of R-7501 is 2500 centistokes and the viscosity of R-7521 is 100 centistokes. Either resin may be thinned by warming to 175 F. If desired, the resins can be blended together to obtain any intermediate viscosity.

The resins are cured by adding a peroxide catalyst and heating at temperatures up to 390 F. Shelf life of the uncatalyzed resins is well over a year; pot life of the catalyzed resins at room temperature is over six months. Dow Corning R-7501 and R-7521 can be used as received or combined with a wide range of inorganic fillers. *No. 419*

Dow Corning Corporation, Dept. 0620, Midland, Michigan

Please send me: 416 417 418 419 420 421 422 423 424 425

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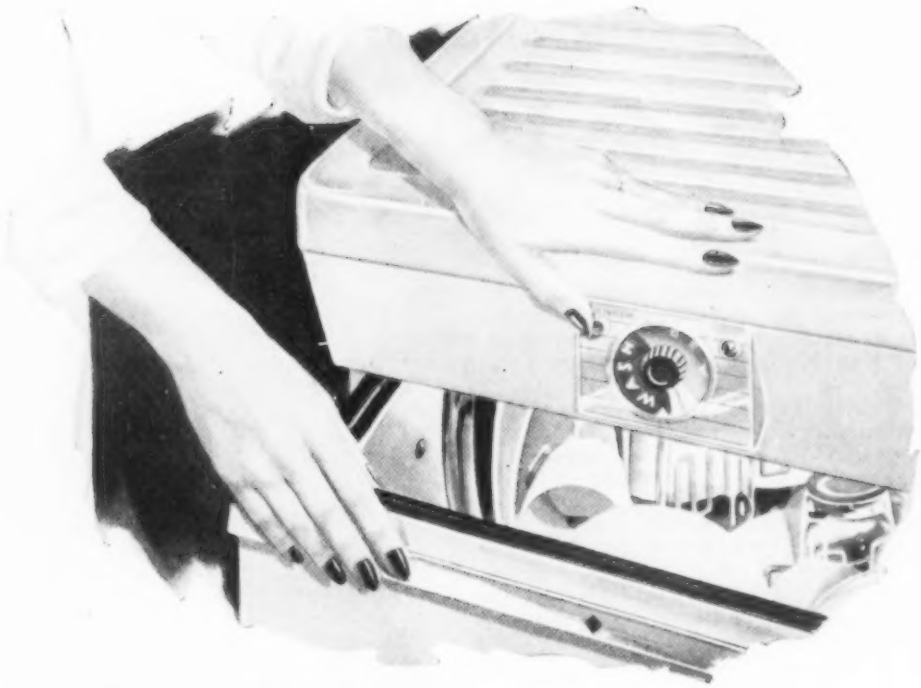


Defeating Drudgery– Task for Mallory Timers

Take the burden of tedious, drudging work out of human hands and make operation automatic—and you have a market ready to buy. This concept has proved itself in automatic home laundries, clothes driers, vending machines . . . and offers interesting possibilities in other types of products for factory and farm.

What makes millions of these self-operating devices and appliances *automatic* is a Mallory timer switch! Designed for ruggedness and versatility, Mallory timers are manufactured to high standards of precision at economical cost, for leading appliance makers.

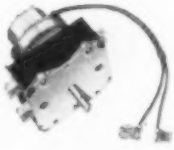
When you are looking for ways to make your new products automatic, you may find that Mallory already has the answer to your timer switch problem. In addition to the Mallory switch that makes a dishwasher automatic, Mallory has other timer switch models—each capable of many variations in cycle time, current rating and other characteristics, cover an almost endless combination of uses. Two of these are illustrated:

For a consultation on your specific automation problem, write or call Mallory today.

For cycles from 1 second to several hours

the new Mallory interval timer controls up to 6 circuits to high precision. Timed portion of the cycle can be adjustable. Motor reset gives positive, spring-less return to original start position. Nominal rating: 10 amperes at 125 volts and 5 amperes at 250 volts; other ratings are possible.

For heavy duty . . .



another Mallory timer controls two 25-ampere circuits. Self-cleaning spring contact assembly has long life, fast opening; ends danger of sticking of contacts. Many variations in motor mounting, built-in bussing and terminal arrangement are available.

Expect more . . . Get more from

P. R. MALLORY & CO. Inc.

MALLORY

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Serving Industry with These Products:

Electromechanical—Resistors • Switches • Television Tuners • Vibrators
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FORD BUILDS FOR THE FUTURE WITH

CYPAK

... controlling form grinder sequencing in automatic transmission production

CYPAK* static controls have already outlasted conventional relays previously used at the Ford plant in Livonia, Michigan. No down time for control maintenance has been necessary with this highly repetitive operation in over 17 months!

Logic and sequencing control of two Springfield Machine Tool Co. form grinders is performed by CYPAK static control apparatus. CYPAK activates the solenoids of hydraulic valves controlling the grinder's feed cycle.

In machining the impeller housing of automatic transmissions, the operator places the workpiece in the chuck, presses the cycle button ... and CYPAK does the rest ... automatically.

For complete information about CYPAK call your Westinghouse representative, or write Westinghouse Electric Corp., Dept. B, P.O. Box 868, Pittsburgh 30, Pa.

*Trade-Mark

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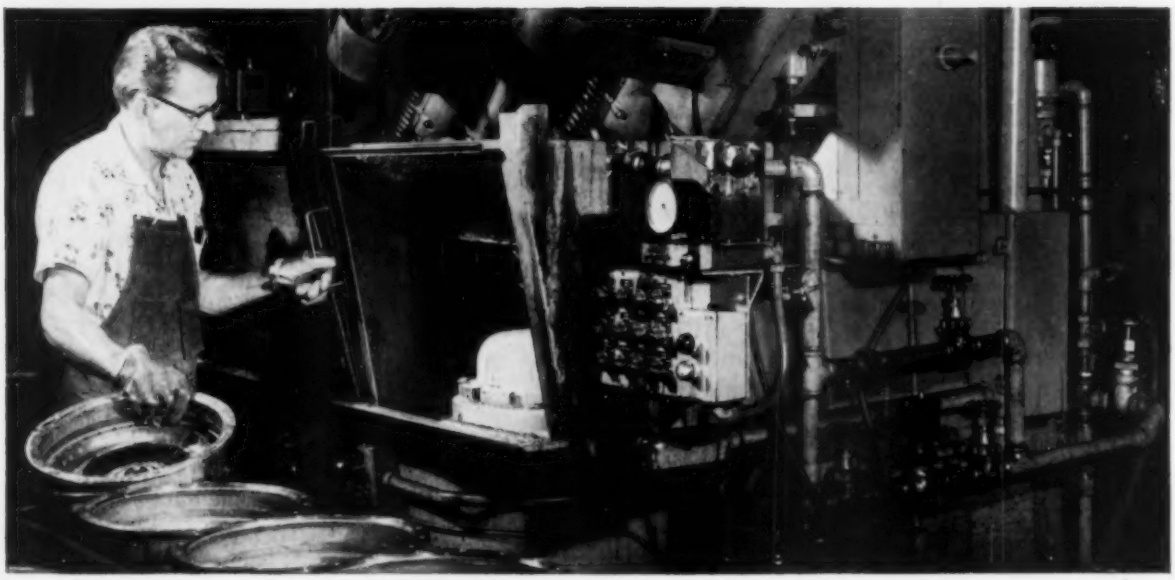
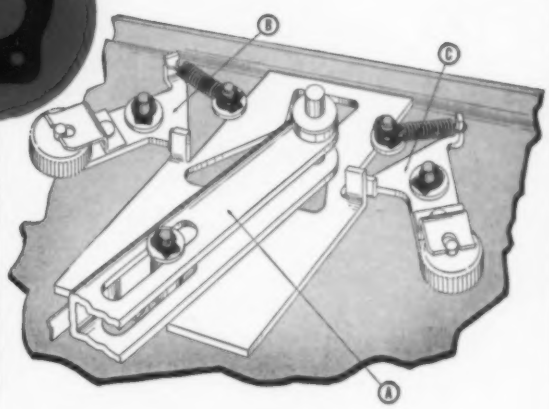
YOU CAN BE SURE...IF IT'S

Westinghouse



Waldes Truarc grip rings used on die-cast studs eliminate threading, tapping, other costly machining

Mark Simpson Manufacturing Co., Long Island City, N. Y., uses Waldes Truarc series 5555 Grip Rings to secure parts to studs of the zinc die-cast base of its "Masco 500" portable tape recorder.
The rings—which need no grooves—replace nuts, screws, cotter pins and other types of fastening devices which require threading, tapping, drilling and other expensive machining operations. Because a single cracked or broken stud would render the entire cast base useless—and with it, all assembly completed to that point—the rings also eliminate extremely costly rejects.



Pivot Assembly of shift lever (A) is secured by a single Waldes Truarc Grip Ring and washer. Because the washer must be installed over the shift level in a sliding fit, critical tolerances would have to be maintained if a screw or cotter pin were used. The Truarc Grip Ring eliminates that problem: it requires no groove and may be seated over the washer at any point on the stud, automatically compensating for accumulated tolerances in the parts. BRAKE ASSEMBLIES (B and C) use Grip Rings to secure the brake wheel and spring subassemblies. Here again problems of critical tolerances are avoided and expensive rejects eliminated.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product... to save you material, machining and labor costs. They're quick and easy to assemble and disassemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

36 functionally different types... as many as 97 different sizes within a type... 5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U. S. A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today... let our Truarc engineers help you solve design, assembly and production problems... without obligation.

For precision internal grooving and undercutting... Waldes Truarc Grooving Tool!

WALDES
TRUARC®
RETAINING RINGS
WALDES KOHINOOR, INC.
47-16 AUSTEL PLACE, L. I. C. 1, N. Y.

Waldes Kohinoor, Inc., 47-16 Austel Place, L. I. C. 1, N.Y.
Please send the new supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.
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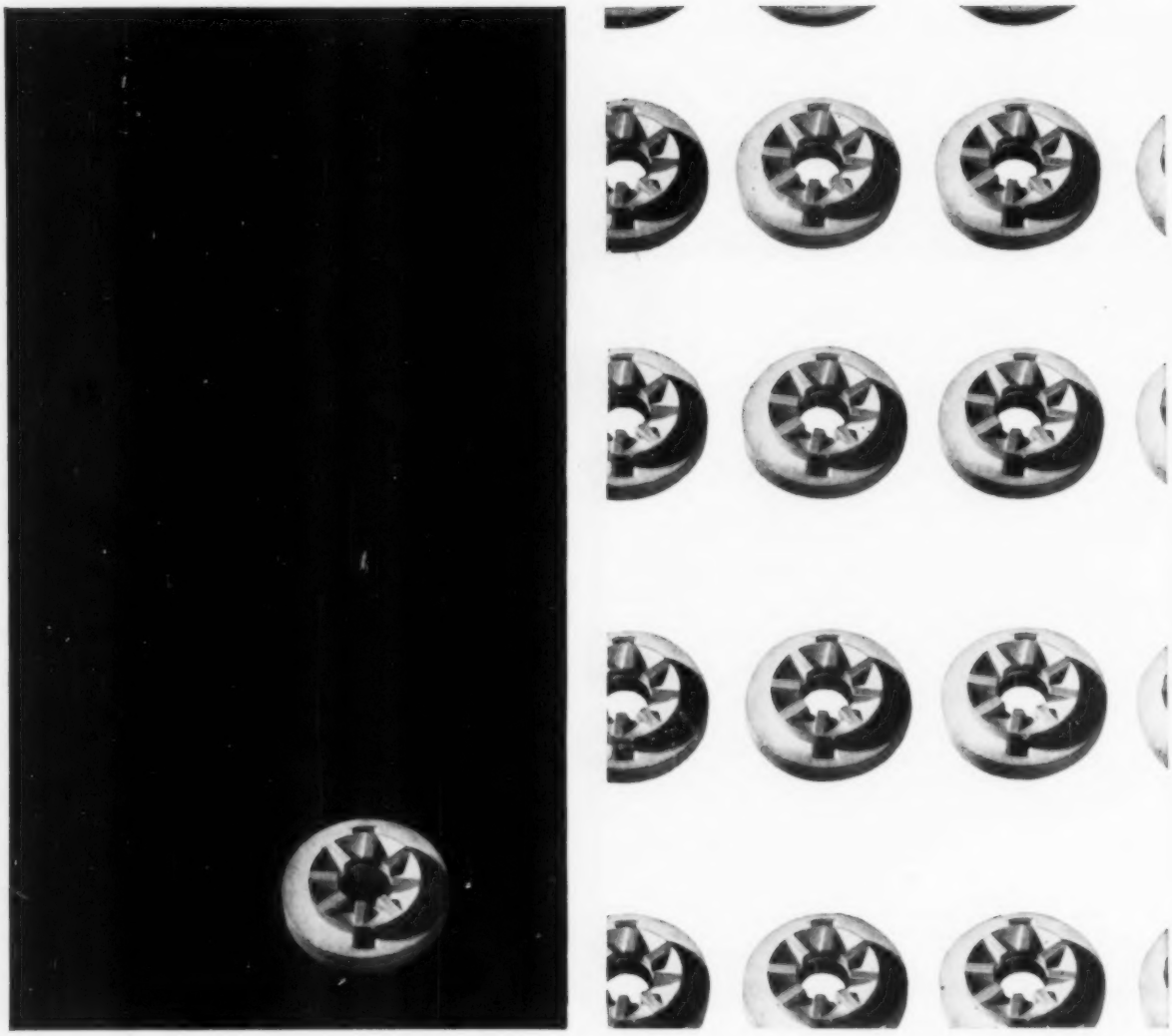
WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.



Does *volume* limit use of metal powder parts?

Yes, it does. For unless volume is sufficient to justify tooling costs, nobody benefits from the metal powder process. But when volume is sufficient, and the design is practical for the metal powder process, savings can be impressive. Even the most complicated part, for example, may be produced in a single press operation. Yet closer-than-ever tolerances are maintained.

Moraine Products also produces: Moraine Power Brakes—Delco hydraulic brake fluids, brake assemblies, master cylinders, wheel cylinders, and parts—Moraine friction materials—Moraine-400 and M-100 automotive engine bearings—self-lubricating bearings and porous metal filters—rolled bronze and bi-metal bushings.

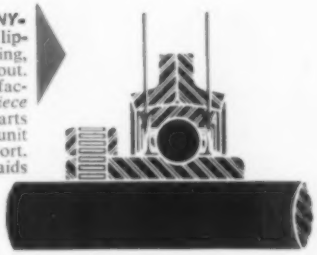
Another General Motors Value

Moraine Products
Division of General Motors, Dayton, Ohio

Precision... self-alignment

EVEN IN THIS LOW-COST BEARING

BEST SEAL AVAILABLE ANYWHERE! Synthetic rubber lip-type seal, integral with bearing, keeps lubricant in, dirt out. Bearing is greased at the factory and shipped in *one piece* . . . no juggling of sundry parts in assembly—simply slip unit on shaft and bolt to support. Its compactness further aids design flexibility.

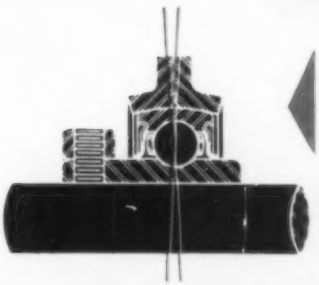


LINK-BELT JPS-200 ball bearings maintain capacity despite shaft and support deflection

IN rugged field service, supporting structures on farm machinery and similar equipment undergo inevitable weaving. Shafts, too, are subject to dynamic deflections. Answer: *self-alignment* — the ability of Link-Belt bearings to adjust under these conditions. And it's yours *at low cost* in this precision Link-Belt ball bearing.

Equally important, Series JPS-200 bearings achieve their economy with *no loss of efficiency*. They combine sturdy pressed-steel housings with standard, full-capacity Link-Belt ball bearings.

Folder 2517 has complete data on the Link-Belt JPS bearing series, and Book 2550 covers the entire Link-Belt bearing line. Get both from any of 40 Link-Belt offices.



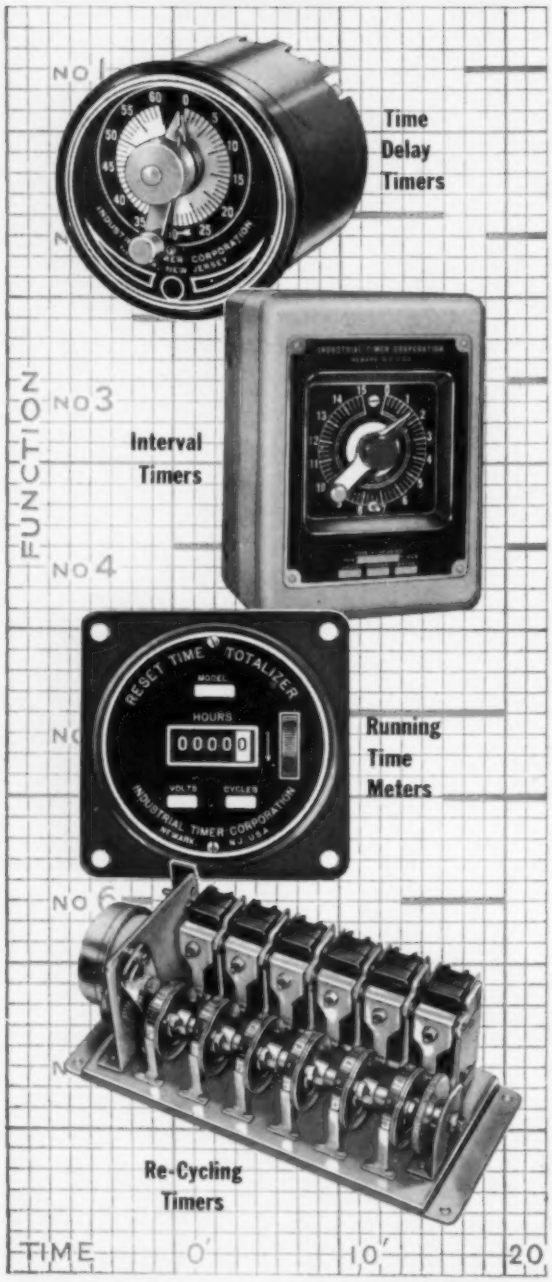
FREE ROLLING AND FULL LOAD CAPACITY are maintained even under shaft or support misalignment with Link-Belt self-aligning feature. Extra-long inner ring of bearing assures proper load distribution. Heavy spring-locking collar firmly secures bearing on shaft.

LINK-BELT

self-aligning ball and roller bearings

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World. 14.339-A

Need a "SPECIAL" TIMER ...need a "STANDARD"?



Here's why WE can give you the fastest service

When you want a timer, you want one that fits your needs 100% — and you want it *fast*. Get in touch with Industrial and you'll get both. Because:

In our 20 years of experience, we have developed *over a thousand combinations* from our 17 basic types, to meet the widely varying needs of our customers. Therefore — many jobs that would seem to require a "special" timer are in fact a "standard" timer with us. Here is one tremendous saving of time for you.

When you *do* need a special timer, this same wealth of experience goes to work for you at once to design it. Our Engineering Department not only originates new designs, but also develops modifications for that purpose. That's why requests for special timers can be filled without delay.

Each method — designing for a standard timer or for a special timer — has its advantages. Designing for an already available timer means lower costs, faster service, simplified replacements.

Designing for a special timer has its advantages too. It means you'll fulfill your needs 100% — no need to limit your designing horizons. Either way — standard or special — you'll get the timer you want most promptly from Industrial.

Or perhaps you need quick service on timers for automatic controls. Here too Industrial Timer is your first source of supply. For in this field Industrial has a big head start. True, each automatic control job is a bit different from the rest. But the record shows that our years of timer experience has given us the special knowledge it takes to give you the right answers in near-record time.

So, for the utmost in all-round timer service, it's Industrial that offers you this outstanding combination: deliveries "Immediate on Standards . . . First on Specials." Plus the experience of one of the foremost group of timer engineers in the nation.

Timers that Control the Pulse Beat of Industry

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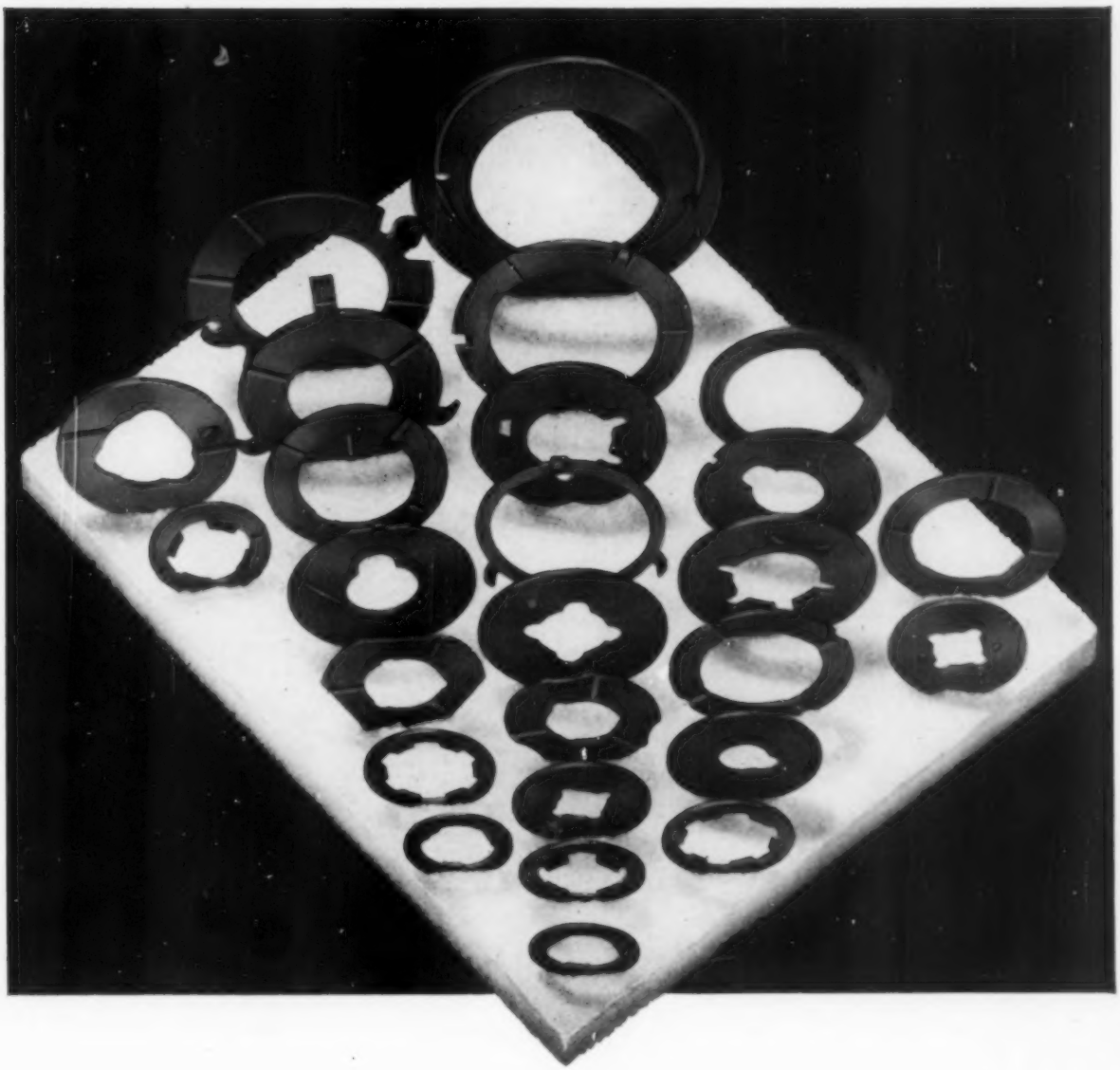

Variety in Precision Thrust Washer Design

Because of specially designed equipment incorporated in our manufacturing facilities, many design variations are possible in our cold-rolled thrust washers. Made of bronze, or steel with bronze on one or *both* faces, they can incorporate special holes, grooves, nibs, scallops or lugs, as required. They can be flat, spherical or special shapes, and from 1″ to 6″ O.D. Cold rolling provides exceptional hardness for heavy duty. We have large capacity and provide complete engineering service. Address:

FEDERAL Mogul
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FEDERAL-MOGUL DIVISION

FEDERAL-MOGUL-BOWER BEARINGS, INC., 11043 SHOEMAKER, DETROIT 13, MICHIGAN

RESEARCH • DESIGN • METALLURGY • PRECISION MANUFACTURING

How many hats do you wear?

IT HAS BEEN SAID that a product design engineer must wear many different hats. First of all, he has to think out a gadget that will do a certain job without falling apart. Then, he has to be a production expert because he has to be sure that his gadget can be *made*. Can it be made economically? He has to know some cost accounting. Has he specified screwball component parts? He has to know a lot about purchasing—what materials are available, when they can be delivered and all the rest.

Since most machines contain some springs, your design engineer should (ideally) also be a spring engineer. But don't you have to draw the line somewhere? The most skilled group of spring engineers in the nation are at your beck and call without any obligation. The men at American Steel & Wire have been specialists all their lives. A problem that is new to you may be old hat to them. More than that, they know spring-making *machinery*, and can suggest design modifications that will allow more efficient production methods. Result? Lower cost for you.

Like they say in the ads, no order is too small or too large. Just call your AS&W representative.

AMERICAN STEEL & WIRE DIVISION
UNITED STATES STEEL, GENERAL OFFICES: CLEVELAND, OHIO
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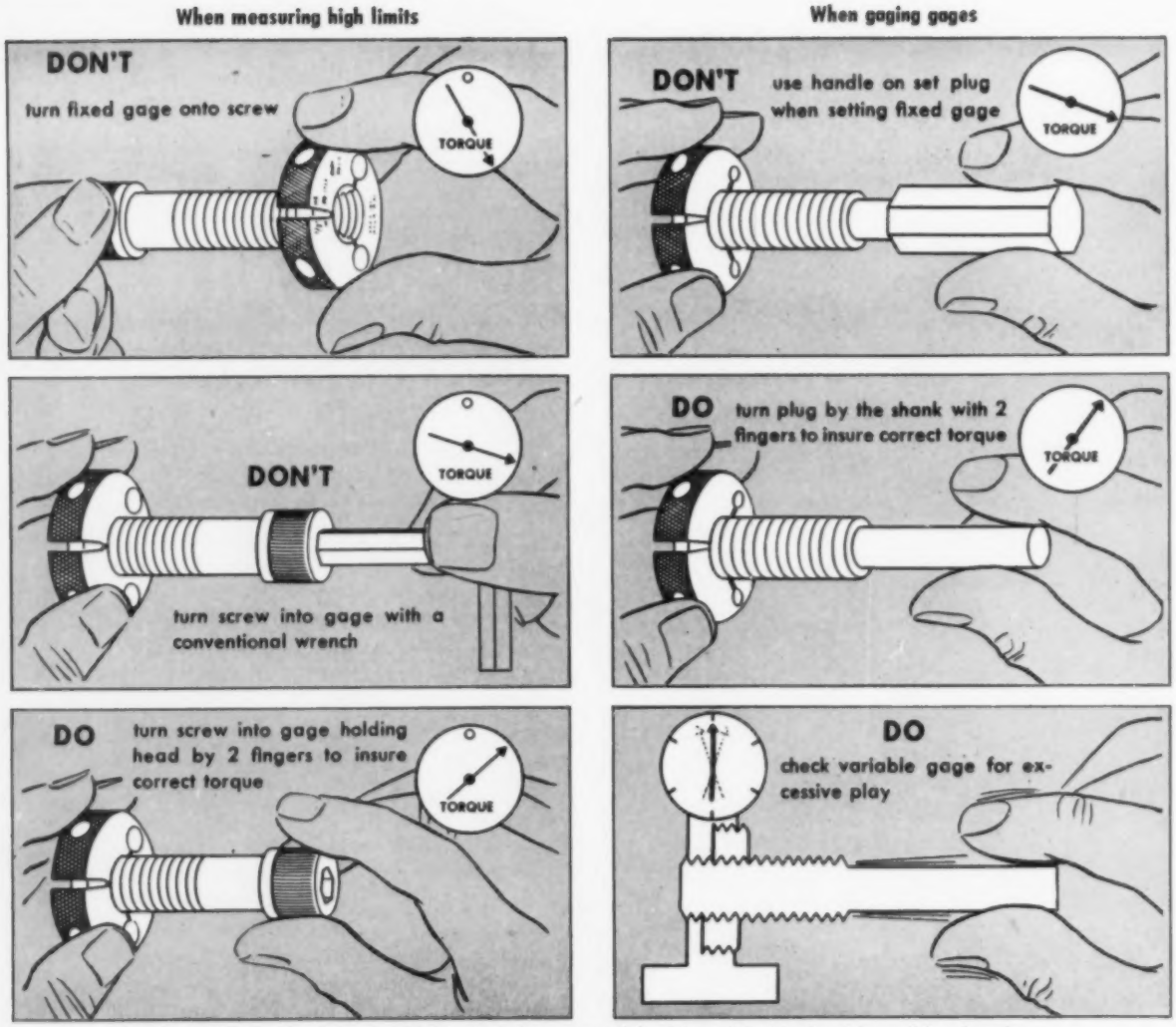


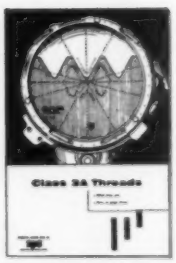
These illustrations from new SPS booklet show some of the do's and don'ts of gaging precision threads.

3A threads: what they are; how to gage them — new SPS booklet tells all

Threads made to Class 3A fit are the most precise in general use in industry. But you do not always get the 3A precision you specify. Because of many different gaging techniques that yield varying results, screws with threads well outside the Class 3A tolerance limits often pass inspection.

SPS has prepared a new booklet on this subject. It explains clearly what Class 3A threads are and the pros and cons involved in the widely varying gaging techniques in use today. It reviews the gaging of high and low limits of 3A threads, sampling techniques, and even the methods of gaging gages.

All standard UNBRAKO socket screw products fall within specified tolerance limits *no matter what method is used to gage them.* Leading industrial distributors carry complete stocks. Unbrako Socket Screw Division, STANDARD PRESSED STEEL Co., Jenkintown 28, Pa.



We also manufacture precision titanium fasteners. Write for free booklet.

Form 2239, "Class 3A Threads: what they are; how to gage them." 16 pages, with many illustrations. Write for free copy today.

STANDARD PRESSED STEEL CO.

UNBRAKO SOCKET SCREW DIVISION SPS

JENKINTOWN PENNSYLVANIA

NOW! IRRIGATION THAT'S TRULY PORTABLE

AND COSTS LESS! THANKS TO ENJAY BUTYL!

Flexible irrigation "pipe" and ditch liners fabricated from Enjay Butyl rubber are helping farmers and growers conserve water by assuring maximum irrigation from available water supplies . . . and at *lower cost!* Combining flexibility with strength and portability, the "pipe" allows irrigation of different areas with the same equipment in a one-man carry operation. Both "pipe" and ditch liners are impervious to weather and highly resistant to soil acids and bacteria. These systems are manufactured by the Carlisle Corp., Carlisle, Pa., and are distributed by Bono Products, Inc., Taft, Texas.

Enjay Butyl may well be able to *cut costs* and *improve the performance* of *your* product! *Low-in-cost* and immediately available, this truly wonder rubber has been put to profitable use in a wide variety of industrial and consumer products. For further information, and for expert technical assistance, contact the Enjay Company.

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Pioneer in Petrochemicals

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

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ENJAY BUTYL

Enjay Butyl is the greatest rubber value in the world. It's the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

HEAT'S AWAY!

Harrison heat-exchangers cool this ultra-modern luxury cruiser!

When engine temperatures are *right*—cruising's on an even keel! And Harrison heat-exchangers are always on the job from launching to landing, helping provide trouble-free operation on this sleek luxury cruiser. You'll find Harrison heat-control products keeping temperatures level on all kinds of equipment . . . marine, automotive, aviation, industrial! That's because Harrison products are backed by over 46 years of engineering research and experience . . . assuring complete dependability in safeguarding performance against heat. If you have a cooling problem, look to Harrison for the answer.

TEMPERATURES MADE TO ORDER

GM GENERAL MOTORS

HARRISON

RADIATOR DIVISION, GENERAL MOTORS CORP., LOCKPORT, N.Y.

MOLY NEWS

CLIMAX MOLYBDENUM COMPANY, 500 FIFTH AVENUE, NEW YORK 36, N. Y.

Super-Strength Structural Steels Boost Minimum Yield Strengths to 150,000 psi.

Seven steel companies in the U. S. are now producing a group of "Super-Strength Structural Steels" with considerably higher yield strengths than the well-known "High-Strength Low-Alloy" steels.

These Super-Strength steels offer minimum yield strengths ranging from 55,000 to 150,000 psi. And they have other useful properties, depending on composition, including strength at moderate temperatures, toughness at low temperatures, and good wear resistance. Almost all of these steels contain molybdenum as an essential element.

The search for steels with greater yield strengths has gone on for many years. Before about 1930, carbon steels with a yield point of roughly 30,000 psi were standard for almost all structural purposes. Then came the development of "High-Strength Low-Alloy" steels. They boosted minimum yields into the 50,000 psi range.

Now, the newer Super-Strength Structural Steels are being welcomed by designers, who see in them a way to solve one of their major problems — to minimize weight and size while retaining quality and reliability.

. . . For more information on these steels, including their trade names and compositions, circle number 1 on the coupon.

Moly's High Hot Strength Shows Promise for Jets and Rockets

Molybdenum-base alloys were described at the 1955 American Rocket Society annual meeting as having the greatest promise for true high-temperature operation.

Missile and powerplant designers are interested in moly mainly for its high temperature strength. Molybdenum-base alloys have been developed with higher useful strength at temperatures over 1600 F than any other presently known metallic material.

The jet propulsion field — including guided missiles and aircraft powered by rocket, ramjet, and turbojet engines — covers a tremendous variety of requirements and service conditions in respect to temperature, atmosphere, amount and type of stress, vibration, thermal shock, and prospective life. Molybdenum's properties make it a logical choice in many cases because it has:

1. High creep and rupture strength.
2. High tensile strength at high temperatures.
3. High modulus of elasticity.
4. A combination of high thermal conductivity, low specific heat, and low expansivity, which minimizes nonuniform temperature distribution and makes molybdenum insensitive to thermal shock.
5. High resistance to erosion by hot gases.
6. High melting point.

It seems safe to conclude that molybdenum-base alloys will become important structural materials in the jet propulsion field. And they will become essential for many parts operating at temperatures in excess of 1600 F.

. . . from "Molybdenum for High strength at High Temperatures," by R. Freeman and J. Briggs, JET PROPULSION, *February, 1957.*

For a copy of the complete article, circle number 2 on the coupon.

Moly Adds Strength and Corrosion Resistance to Titanium

Commercially pure titanium is fairly strong and highly corrosion-resistant. Alloying it, however, substantially increases these useful properties.

Molybdenum may prove to be one of the most useful of the alloying elements for titanium. Studies at Armour Research Foundation, for example, show that when molybdenum is used instead of vanadium, creep properties are greatly improved. At 1020 F, a stress of approximately 20,000 psi produces a creep rate of 10^{-4} in. per in. per hr in Ti-6 Al and Ti-6 Al-4 V, whereas 40,000 psi is required to produce the same creep rate in a Ti-7 Al-3 Mo alloy.

In summary, new alloy development is opening the way for titanium's extensive use in jet engines and air frames. Ti-Al-Mo alloys, for example, give better elevated temperature properties than the Ti-6 Al-4 V alloy now most widely used. And the alloy containing 7% Al and 3% Mo appears particularly promising.

Another Ti-Mo alloy contains 30 to 40% Mo. This alloy is claimed to resist boiling 40% sulphuric acid and boiling 20% hydrochloric acid as well as platinum, tantalum or gold. Such a retained beta alloy is weldable and could be fabricated into sheet. These corrosion-resistant characteristics would add to the value of all-beta Ti-Mo alloys.

. . . from "Molybdenum as an Alloy Addition for Titanium," by Harold Margolin, METAL PROGRESS, *February, 1957.*

For a copy of the complete article, circle number 3 on the coupon.

Moly Goes to Sea In A Sewer

Cast iron joint ring in pipe, before lowering into position. Joint rings were made by Alhambra Foundry Co., Ltd. and the concrete pipes poured by American Pipe and Construction Co.

Positioning 64 ton reinforced concrete sewer pipe sections puts quite a strain on the cast iron joint rings used to join them. Especially when the job is done under water at depths up to 210 feet.

Joint rings must be strong enough to withstand stresses developed when the pipe is drawn together, plus sufficient impact resistance to withstand handling and placement.

Those are good reasons why the County Sanitation District No. 2 of Los Angeles County specifies ASTM A 48, class 40 iron for the rings. In addition to the required 40,000 psi, tensile strength, and 2600 lb transverse strength minimum, (on a 1.2 in. test bar), the bar must be capable of deflecting at least 0.20 in. and the iron must contain at least 0.40% Cr, 0.60% Cu and 0.35% Mo.

Examination of pipe lengths after six years' service showed them in excellent condition. Equally good performance is expected from the most recent installations which extend some 8000 feet into the Pacific Ocean, and are believed to be among the largest in the country.

. . . For more information on the contribution of moly to toughness and shock resistance of cast iron, circle number 4 on the coupon.

Climax Molybdenum Company, Dept. 61,
500 Fifth Avenue, New York 36, N. Y.

I'd like more information on:
1 2 3 4

Name_____

Address_____

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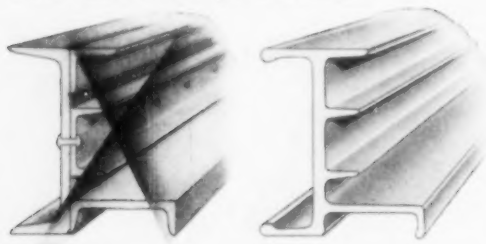
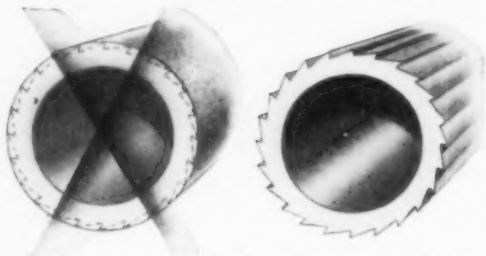
Cost-Cutting Aluminum Extrusions . . .

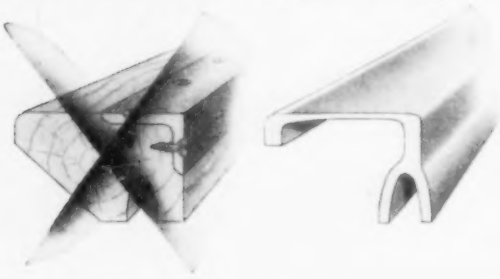
1. eliminate joining



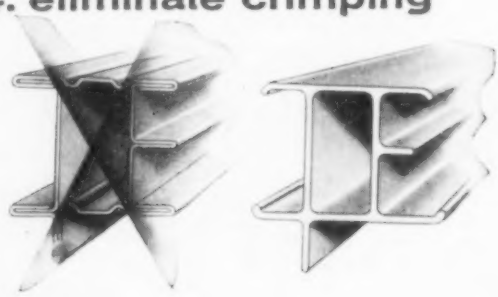
2. eliminate machining



3. eliminate reinforcing



4. eliminate crimping



HERE'S ONE WAY EXTRUSIONS SAVE AND IMPROVE . . .

NEW

Reynolds "ALL-AIR" * truck flooring

Here's a new Reynolds extruded aluminum product that really saves . . . both in production and in use. Made of simple, strong interlocking extruded aluminum panels, this new "All-Air" reefer flooring gives truck operators the light weight and heavy duty service they want. It would be impossible to produce this efficient, cost-cutting flooring any other way, in any other metal.

* TRADE MARK, U.S. PAT. PENDING

The Finest Products Made with Aluminum are made with REYNOLDS ALUMINUM

It's quite likely that your plant is producing part of a product that could be improved—at a lower cost—by an aluminum extrusion. You can turn out the most complex shapes through low-cost, accurate extrusion dies—and you can often minimize or eliminate machining, joining and finishing operations.

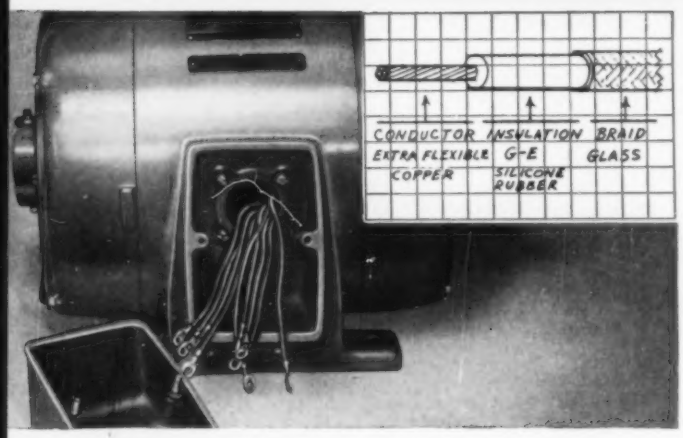
For example, in No. 1 above, a single aluminum extrusion replaces several rolled structural shapes that have to be joined. In No. 2, extruded aluminum tubing does away with the need for machining ordinary tubing or rod. Or, in No. 3, a stiffer, lighter, stronger extruded aluminum shape does the work of a wood-supported metal angle. And, as in No. 4, an aluminum extrusion provides the required shape with added stiffness and without investment in expensive roller dies.

Reynolds Design and Engineering Services will work with engineers and design consultants in improving and cutting the cost of your products with extrusions and other forms of aluminum. For their assistance or to obtain a complete aluminum literature and movie index, call the Reynolds office, listed under "Aluminum" in your classified phone book. Or write *Reynolds Metals Company, P. O. Box 1800-HN, Louisville 1, Kentucky.*

HOW TO SOLVE
PRODUCT DESIGN PROBLEMS WITH

GE SILICONE IDEAS

APPARATUS LEAD WIRE

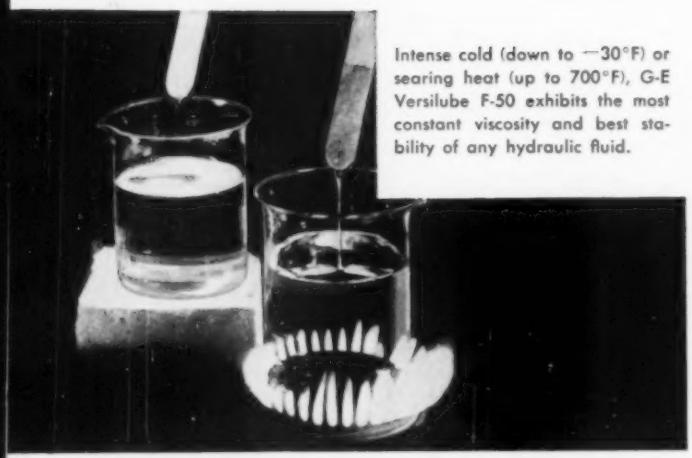


Problem: *Eliminate a potential failure point, upgrade Class B equipment for temporary overloads.*

Solution: Lead wire insulated with G-E silicone rubber.

Silicone insulation, the standard for Class H equipment, enables manufacturers to make smaller, more compact motors, generators, and transformers. Class B equipment can also be upgraded to provide a safety margin for intermittent high temperature operation through the use of silicones. For example, silicone insulated lead wire eliminates a major source of failure in Class B motors, lets you standardize on one type of lead wire for both Class B and H equipment. Motor and apparatus lead wire made with G-E silicone rubber withstands moisture and has ozone resistance approaching that of mica. It is easy to strip and solder and is flexible at low temperatures.

HYDRAULIC FLUID



Intense cold (down to −30°F) or searing heat (up to 700°F), G-E Versilube F-50 exhibits the most constant viscosity and best stability of any hydraulic fluid.

Problem: *Find a hydraulic fluid that functions over the −30°F to 700°F range.*

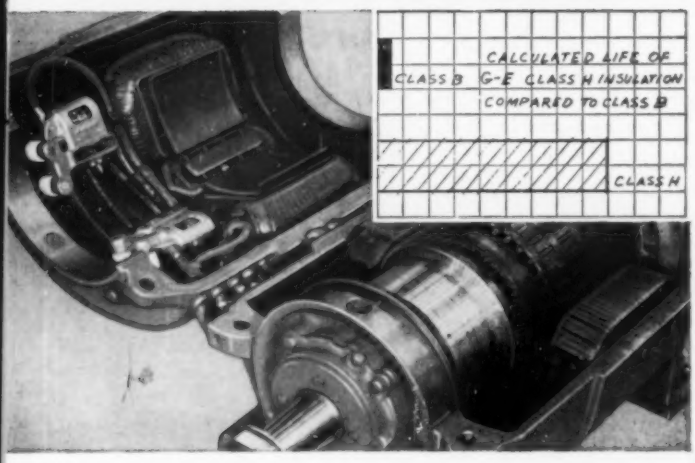
Solution: *Versilube* F-50, General Electric's new silicone fluid, with the best performance over this range of any hydraulic fluid now available.

Over the −30°F to 700°F range, *only* General Electric's new silicone fluid, Versilube F-50, provides adequate performance in all these areas: thermal stability, lubricity, viscosity-temperature coefficient, oxidative stability, oxidation threshold temperature and hydrolytic stability.

No other serviceable hydraulic fluid matches the thermal stability of G-E Versilube F-50—up to 600°F and for many applications, up to 700°F. Its lubricity is unequalled at temperatures as high as 700°F and comparable to other hydraulic fluids in the moderate ranges. Versilube F-50 also maintains a more nearly constant viscosity than other hydraulic fluids over the −30°F to 700°F range.

For more information about Versilube F-50 and other G-E silicone fluids, send the coupon below.

CLASS H DC MOTORS



Problem: *Design a coil for DC motors that will eliminate insulation failure and increase normal operating life at least 10 times.*

Solution: Combine inorganic materials with G-E silicones in an improved insulation system.

Auxiliary mill motors often meet unexpected high ambient temperatures, unforeseen extra long duty or other emergency conditions—any of which can cause "roast-outs." This problem has been solved by a Class H G-E silicone insulation system which will withstand continuous high temperatures. Silicone-treated mica mat is used on commutating, exciting field and armature coils. In laboratory tests, this insulation has maintained full dielectric strength after 3½ months at 300°C.

Service life of this insulation has been calculated to be 32 times that of conventional Class B insulation. Actual tests with Class H and B motors coupled together prove that insulation with G-E silicones lasts more than 5 times as long. Five Class B motors have consecutively burned out; the Class H is still going strong.

Mail this coupon for more information:

GENERAL ELECTRIC

Silicone Products Department, Waterford, New York

Section D2A8, Silicone Products Dept.
General Electric Company, Waterford, N. Y.

Please send me more information on

☐ silicone rubber for wire and cable insulation, including list of suppliers ☐ Class H insulation

☐ silicone fluids for mechanical applications ☐ I also want data on:

_____

Name_____ **Position**_____

Company_____

Address_____

City_____ **Zone**_____ **State**_____

OVER-DESIGNING?

If you are designing bronze parts for mass production, there is a good chance that you are specifying a more costly alloy than you need.

ASARCO's patented continuous-casting process produces alloys according to SAE, ASTM and Government specifications. But their performance is entirely unlike that of similar alloys cast in sand or permanent molds. Relatively low-cost alloys cast by the ASARCO process perform like more expensive alloys cast by other methods.

For example, compare Continuous-Cast SAE 660 (ASARCON 773) with more expensive sand-cast alloys:

	Typical Yield Strength	Typical Impact Strength	Brinell Hardness
ASARCON 773	27,000 psi	12.5 ft.-lbs.	72
Sand-Cast SAE 62	20,000 psi	8.7 ft.-lbs.	65
Sand-Cast SAE 64	17,000 psi	8.2 ft.-lbs.	62

Unless you've checked to see whether the unique ASARCO bronzes can give you what you need, there's a possibility that you're over-designing. You may even be able to replace aluminum and manganese bronzes with low-cost ASARCON Continuous-Cast bronzes under certain conditions. Over-designing can be expensive in mass production, even if you are spending only a penny or two extra per pound of bronze.

ASARCON 773 (SAE 660) is readily available from stock in a wide range of sizes. An added bonus is the fact that ASARCON 773 is exceptionally free-machining. Rods, tubes, and numerous "extruded" shapes up to 9 inches in diameter are cast to order by ASARCO in more than 20 alloys.

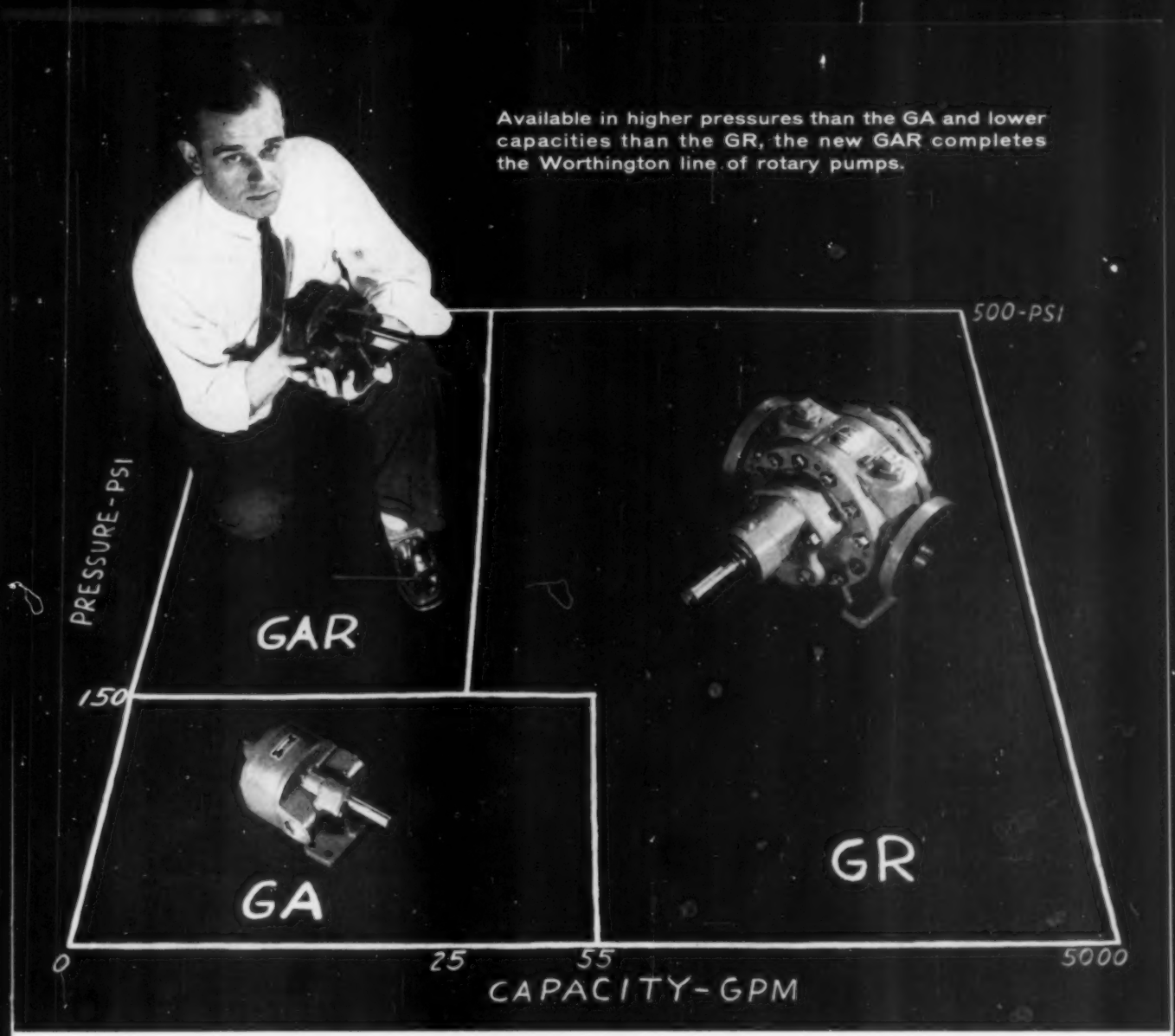
We'll be happy to send you a free booklet describing the process and the product.

Continuous-Cast Products Department

AMERICAN SMELTING AND REFINING COMPANY

Perth Amboy Plant, Barber, New Jersey • Whiting, Indiana

WEST COAST SALES AGENT: Kingwell Bros. Ltd., 457 Minna Street, San Francisco IN CANADA: Federated Metals Canada, Ltd., Toronto and Montreal



NEW ROTARY PUMP

offers new economy in high pressure, low capacity range

Why sacrifice space, economy, and efficiency in high pressure, low capacity pumps? Here is a new line of internal roller bearing, herringbone gear pumps, designed for continuous operation up to 500 psi in capacities to 25 gpm.

The new Worthington GAR pump is a flexible, rugged unit which provides long trouble-free service. Available in either foot-mounted or Monobloc design, it features heavy-duty, hardened steel roller bearings, nodular iron, double helical gears, and steel backed bronze filler plates which set it apart from the field.

The new GAR is just one of Worthington's complete line of rotary pumps—broadest on the market. Worthington offers 142 different standard rotaries to choose from plus many optional features such as mechanical seals and relief valves. Each pump is factory tested before shipment.

Preferred by users everywhere, Worthington rotaries are backed by service outlets throughout the country. See your Worthington representative for more information or write for descriptive bulletins. Address Section SP-74, Worthington Corporation, Harrison, N. J. In Canada: Worthington (Canada) 1955 Ltd., Brantford, Ont.

WORTHINGTON

STEEL TUBING TIPS:

HOW TUBING ENGINEERS CAN HELP YOU PLAN FOR VOLUME PRODUCTION SAVINGS!

GM Steel Tubing Engineers offer cost-saving fabrication advice at the design stage!

Designers of automotive, refrigeration and other products have found that GM Steel Tubing Engineers can offer many cost-saving tips *in the planning stage.*

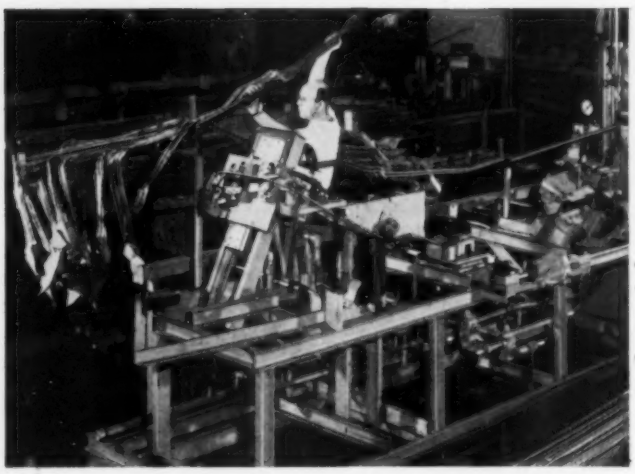
Industry standards are sometimes sufficient when designing a simple tubing application. But a review by the tubing engineer can often suggest changes which will effect greater economies in volume production.

For example, it is usually more economical to incorporate tubing of minimum thickness and diameter. However, the tubing engineer, with his knowledge of tubing manufacture, can tell you when a greater wall thickness or diameter will achieve greater economies.

And the tubing engineer's knowledge of fittings will help you at the planning stage. Based on operating conditions, he can recommend the fitting that will work best at the least cost. Keeping up with the latest tubing advances also makes it possible for him to show you how to take advantage of savings with tubing for fabricated parts and mechanical applications other than fluid or gas carriers.

The design of formed steel tubing connecting lines is another area where the tubing engineer can be of great help to the designer. Again, standards and rules may prove inadequate if you are to be absolutely sure of the most economical part to do the job. The tubing engineer can tell you how to get the greatest number of bends for the least cost, how tubing will react when formed by various methods to give you the most efficient design.

When designing any product requiring tubing, consult your GM Steel Tubing Sales Engineer *in the planning stage.* Or, for general information, write direct to: Tubing Sales Manager, Rochester Products Division of General Motors, Rochester, New York.



Hydraulic forming fixtures like these at Rochester Products can be adapted to handle your requirements at minimum tooling costs. GM Steel Tubing Engineers offer you an unequaled choice of fast, cost-cutting forming equipment, let you plan production savings in the preliminary design stage.

GM Steel Tubing gives you the design flexibility of lengths up to 2000 feet. Eliminate costly joints and elbows, effect additional savings by cutting end waste.

GM STEEL TUBING by ROCHESTER PRODUCTS

Model 47J Bell Helicopter

Garlock KLOZURES* Specified on Bell Helicopters for 10 years

Since 1947 Bell Helicopter Corporation engineers have consistently specified Garlock KLOZURE Oil Seals for twelve different sealing functions. These KLOZURES serve in both low speed and high speed capacities contributing in no small measure to the outstanding performance and leadership of Bell Helicopters in that industry. Bell reports these seals have a minimum satisfactory life exceeding the required 600 hour overhaul.

The standard sealing element in a Garlock KLOZURE Oil Seal is a unique synthetic material molded to very accurate dimensions. It is non-abrasive, free-running; resistant to oil, grease, heat, and cold; impervious to water, mild acids, and alkalies. It is also extremely durable and resilient. For unusual service requirements sealing elements made of silicone rubber for temperature extremes or Teflon for resisting strong acids and other chemicals can be obtained.

A long list of satisfied users is added assurance that Garlock KLOZURES provide trouble-free bearing protection . . . sealing-in lubricants . . . sealing out abrasive dust and dirt. If you have a sealing problem, why not ask your Garlock representative for his recommendation from "The Garlock 2,000" . . . two thousand different styles of packings, gaskets, and seals for every need. The only complete line in the industry.

*Registered Trade Mark

Cross-section of Model 51 Garlock KLOZURE Oil Seal designed for medium-speed rotary service and low pressure reciprocating service. This seal is used in the Transmission Assembly and in the Tail Rotor Gear Box of the 47J Bell Helicopter.

WRITE on company letterhead for new KLOZURE Catalog 20. 79 pages of helpful information on oil and grease seals for bearings.

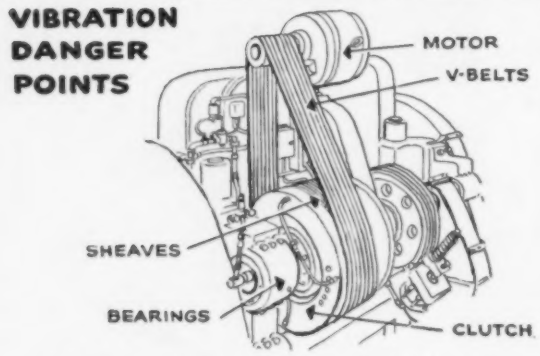
THE GARLOCK PACKING COMPANY, Palmyra, New York

For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.

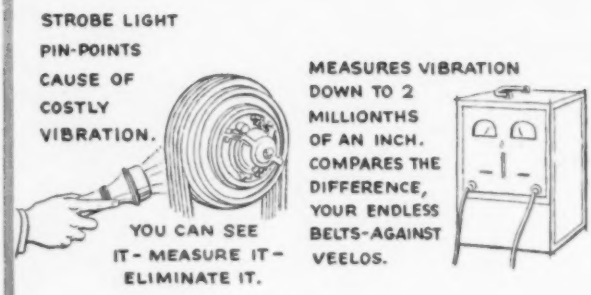
GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Rubber Expansion Joints, Fluorocarbon Products

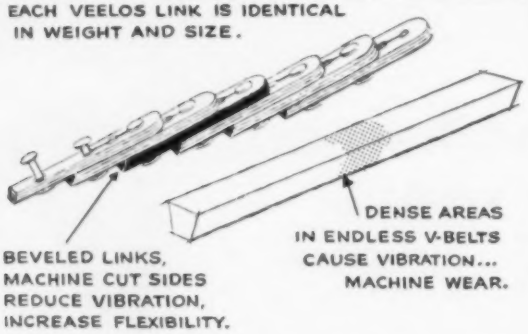
Here's Proof! Veelos Adjustable V-Belts Stop Costly Vibration in Your Drives



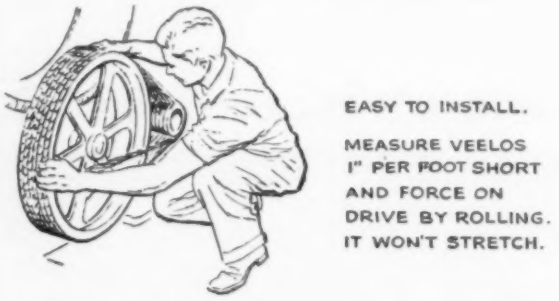
1. Watch out for these danger points. Machine vibration is caused by out-of-balance: in the motor, bearings, clutch, sheaves or V-belts. Often it is in the V-belts alone. This deadly vibration results in excessive machine wear, costly breakdown. But there's no need to guess or worry —your Manheim Veelos salesman can spot V-belt vibration in 15 minutes.


STROBE LIGHT PIN-POINTS CAUSE OF COSTLY VIBRATION.
YOU CAN SEE IT - MEASURE IT - ELIMINATE IT.
MEASURES VIBRATION DOWN TO 2 MILLIONTHS OF AN INCH. COMPARES THE DIFFERENCE, YOUR ENDLESS BELTS-AGAINST VEELOS.

2. Veelos offers you electronic proof! Your Manheim Veelos salesman will prove that Veelos cuts V-belt vibration up to 89% *more* than any belts you're now using. This amazing vibration analysis pin-points the belt that has the "invisible shakes" . . . and tells you exactly how much money-costing vibration is present. You owe it to yourself and your company to see this Veelos V-belt test.

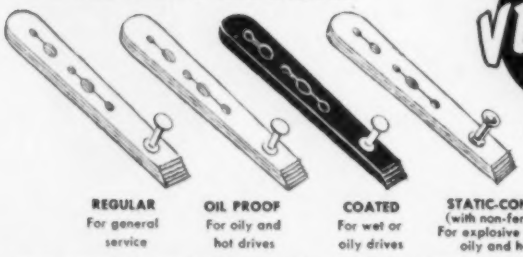

EACH VEELOS LINK IS IDENTICAL IN WEIGHT AND SIZE.
BEVELED LINKS, MACHINE CUT SIDES REDUCE VIBRATION, INCREASE FLEXIBILITY.
DENSE AREAS IN ENDLESS V-BELTS CAUSE VIBRATION... MACHINE WEAR.

3. Install Veelos for smoother drives! Balanced construction of Veelos belts assures you faster, cleaner work, less rejects—less bearing wear. Each Veelos link and stud is identical in size and weight. As you know, endless belts have varying spots of density which cause excess vibration. This excess vibration increases chatter marks, machine wear and overall poor production output.



4. Veelos won't stretch any more than any other V-belt, when correctly installed on properly belted drives. Remember to follow the simple instructions on every reel—measure Veelos 1" per foot short of pitch length and roll on drive as tightly as possible. When installed this way, tension may *seem* excessive. However, this initial tension drops to normal when drive begins to run.

4 TYPES FOR ALL DRIVES



REGULAR For general service

OIL PROOF For oily and hot drives

COATED For wet or oily drives

STATIC-CONDUCTING (with non-ferrous studs) For explosive atmosphere, oily and hot drives

For all sizes and types of drives. Double-V available for serpentine drives.

VEELOS® THE BALANCED LINK V-BELT

Known as Veelink outside U.S.A.

MANHEIM

451 Qualified Distributors

Write for free Veelos Data Book or Veelos Vibration Demonstration to: Manheim Mfg. & Belting Co. **807** Stiegel St., Manheim, Pa.

"Industrial Belt Specialists since 1911"

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Helpful Data from
DE LAVAL

How to calculate the efficiency of worm gearing

The efficiency of worm gearing is determined by frictional losses at the tooth contact, bearings and oil seals plus losses from oil churning and windage. A formula for efficiency at the tooth contact may be developed from a consideration of the forces at the contact. Figure 1 shows these forces acting on a developed section of the worm thread. For simplicity the pressure angle has been assumed to be zero.

The coefficient of friction of the worm and gear is a function of the materials, finish, lubrication and rubbing speed. The latter is the relative speed between a point on the pitch surface of the gear and one on the pitch surface of the worm. The coefficient of friction varies very little at high rubbing speeds but rises with increasing rapidity as the speed drops below 500 fpm.

The efficiency formula developed in Figure 1 involves worm lead angle and the friction angle. Figure 2 provides a relationship between friction angle and rubbing speed based on tests made on accurately manufactured gearing consisting of hardened and ground worm and bronze gear operating in oil.

The formula for rubbing speed is:

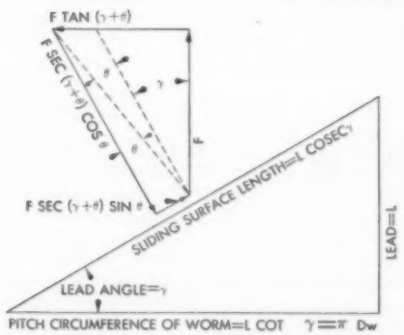
$$V = \frac{.262\ Dw \times \eta}{\cos \gamma}$$

where

V = Rubbing speed – feet per minute
Dw = Worm pitch diameter – inches
η = Worm speed – rpm
γ = Worm lead angle

FIGURE 1.

Development of equation for efficiency at contact between worm and gear



F = TANGENTIAL FORCE ACTING ON GEAR

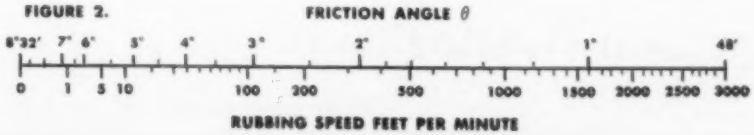
F TAN ($\gamma + \theta$) = TANGENTIAL FORCE APPLIED TO WORM

F SEC ($\gamma + \theta$) COS θ = FORCE NORMAL TO CONTACT SURFACE

F SEC ($\gamma + \theta$) SIN θ = FRICTIONAL FORCE

$$\text{EFFICIENCY} = \frac{\text{WORK REALIZED}}{\text{WORK APPLIED}} = \frac{L \times F}{L \cot \gamma \times F \tan (\gamma+\theta)} = \frac{\tan \gamma}{\tan (\gamma+\theta)}$$

FIGURE 2.



DE LAVAL Worm Gear Speed Reducers Offer Efficiencies to 96%

Ruggedly built for long efficient service De Laval speed reducers are made in horizontal and vertical single reduction units in ratios of 3:1 to 100:1. They are also available in double horizontal and vertical double reduction units as well as in helical-worm and double-worm design. Ratios from 37.8:1 up to 6400:1.

Write for your copies of Catalogs G-WBV and G-WWH to De Laval Steam Turbine Company, Trenton 2, New Jersey.

MORE HORSEPOWER!

LESS COST!

SMALLER SPACE!

with Westinghouse rerated motor starters

Here's real news for cost-conscious, space-conscious electrical planners.

Westinghouse Life-Linestarters® (sizes 0 and 1) *have been uprated* . . . giving you the advantages of more horsepower, less space, lower cost!

For example: if you've been controlling a 440-volt, 5-hp polyphase motor with a size 1 starter, you can get the identical control and protection with the smaller, less costly size 0 starter.

And speaking of performance . . .

Only Westinghouse starters have the De-ion® arc quencher, which greatly increases contact life by reducing burning and pitting.

Westinghouse starters utilize high-strength, non-carbonizing Rosite insulating parts for maximum safety and operating life.

Westinghouse starters have double-break, silver-to-silver contacts for longer life and greater dependability.

What's more, the entire starter line is designed to simplify installation and maintenance — featuring front-removable parts and straight-through wiring.

For the full story, contact your nearby Westinghouse sales office. Or write Westinghouse Electric Corporation, Standard Control Division, Beaver, Penna. J-30280

NEMA SIZE	110 Volt				220 Volt				440-600 Volt			
	1ø		3ø		1ø		3ø		1ø		3ø	
	Old Rating	New Rating	Old Rating	New Rating	Old Rating	New Rating	Old Rating	New Rating	Old Rating	New Rating	Old Rating	New Rating
0	1	1	1½	2	1½	2	2	3	1½	3	3	5
1	1½	2	3	3	3	3	5	7½	5	5	7½	10

Westinghouse uprated starters give you: More horsepower — in eight new starter ratings. Less cost and space — in applications where the rerated size 0 starter replaces the size 1 starter, and the size 1 replaces the size 2.

YOU CAN BE SURE...IF IT'S Westinghouse

REVERE COPPER EXTRUSION shown attached to skirtboard before full assembly, which you can see below in exploded view. A matching bar, similar to the one shown is part of the "packaged" HANCO unit and is fastened to the opposite side of the screen. Units, in turn, are installed on the various types of Vibrating Screens made by HEWITT-ROBINS INC., Passaic, N. J., and are known as the HEWITT-ROBINS HANNON Electric Screen Heaters.

CLOSE-UP showing end of the Revere Copper Extrusion.

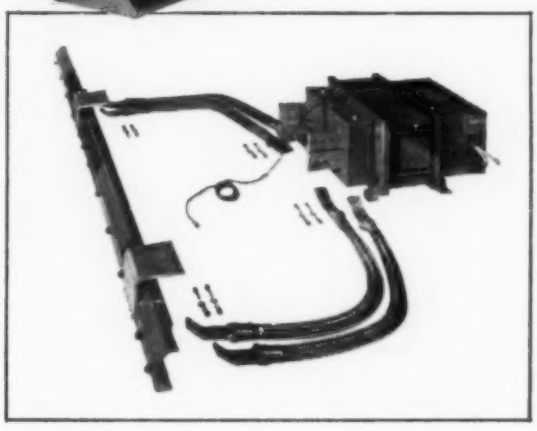
Revere Copper Extruded Shape

in Hanco Electric Screen Heater

out-performs

former copper casting

on 4 counts



"Customers of F. R. Hannon & Sons are now assured of many years of maintenance-free performance plus improved products."

Says T. W. HANNON, *Vice-President, General Manager*
F. R. HANNON & SONS, Canton, Ohio

Mr. Hannon continued, "For a number of years we had experimented with many different types of materials which would be non-porous, free from any burrs or voids, capable of maintaining a straight leading edge and able to carry 1500 amperes at 5 volts. The Revere Copper Extrusion meets these requirements. And for the rugged use to which our machines are put it would be virtually impossible to maintain satisfactory operating results without the use of this extruded electrical conductor."

Perhaps there is a Revere Product that can help you give *your* customers a superior product, or help cut your production costs. You'll never know until you call the Revere Office nearest you and ask to have a T. A. (Technical Advisor) call. Why not make that call today?

Here's the Score!

COPPER EXTRUDED SHAPE	COPPER CASTING
1—12 foot mill lengths offer flexibility, eliminating both welds and scrap	1—60" casting required additional welded joints
2—Shape offers lack of porosity	2—Casting gave porosity problem
3—Shape straightness is superior to casting, giving better electrical contact	3—Bow in casting presented difficulty when fastening screen firmly to contact
4—Higher cost per foot, but cheaper over-all installation	4—Initial cost was lower, but additional welds and scrap resulted in higher final cost, and an inferior finished product

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Standard FLEXLOC self-locking locknuts are available in a wide range of standard sizes, types and materials to meet the most critical locknut requirements. Your local industrial distributor stocks them. Write us for complete catalog and technical data. Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 28, Pa.

We also manufacture precision titanium fasteners. Write for free booklet.

FLEXLOC® LOCKNUT DIVISION

STANDARD PRESSED STEEL CO.

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STAINLESS STEEL MAKES THE DIFFERENCE

...its effect on modern castings

Through modern casting techniques, you can get all the useful qualities of stainless steel in everything from small intricate parts to large precise shapes.

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This combination of stainless steel and casting techniques gives design engineers a powerful tool to improve the effectiveness and "sales appeal" of their designs. For more information, write: ELECTRO METALLURGICAL COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.

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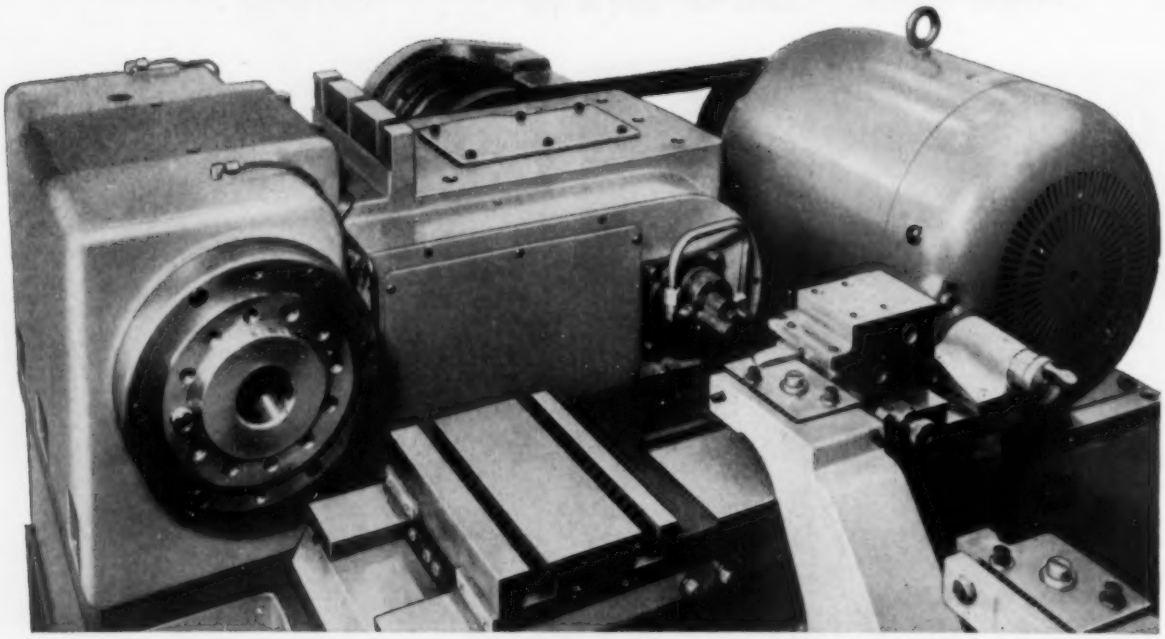
WAGNER ELECTRIC MOTORS...THE CHOICE OF LEADERS IN INDUSTRY

WAGNER MOTORS mean less down-time for production machinery



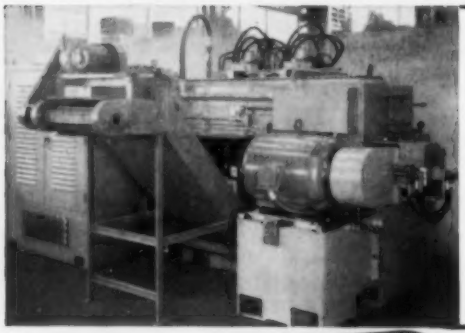
This Wagner Type EP Motor is mounted on the base of the Reedmatic Production Lathe.

Wagner totally-enclosed fan-cooled motors will give your machine tools the drives they need to give continuous service.

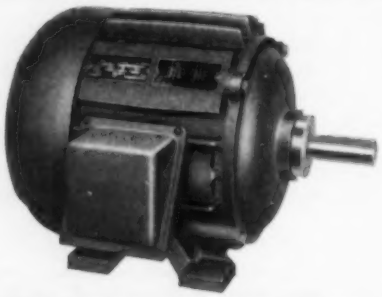
THEY ASSURE LESS DOWN TIME. Wagner totally-enclosed fan-cooled motors are *fully* protected against damage from steel filings, chips, dust, dirt, fumes and moisture. This built-in protection assures freedom from excessive down time caused by motor failure.

THEY REDUCE MAINTENANCE COSTS. Wagner totally-enclosed motors require no maintenance other than periodic lubrication. These motors are designed to run cooler and longer between maintenance periods, but when greasing is necessary, readily accessible lubrication openings permit addition of grease or a complete relubrication.

A Wagner field engineer will be glad to help you design non-stop performance into your production machinery by recommending the motors that best fit your specific needs. Just call the nearest of our 32 branch offices.



This Reed-Prentice tracer controlled automatic production lathe, which turns automobile axles in 30 seconds, is equipped with Wagner Type EP totally-enclosed fan-cooled Motors. These motors are fully described in Bulletin MU-203. Write for your file copy today.



M57-6

Wagner Electric Corporation
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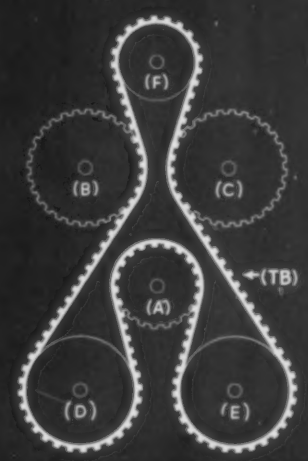
PowerGrip "TIMING" BELTS

"Here's how to make a vacuum cleaner disappear or appear... all by itself," says "GRIP" POWERS

In this schematic of the hose retraction and extension mechanism of the EasyWay Vacuum Cleaner,* the 12-groove drive pulley (A) is powered by a ¼ h.p., 1750 r.p.m. electric motor. The power is transmitted—*through a single U.S. PowerGrip "Timing" Belt (T-B)*—to four pulleys. Two of these (B & C) are 26-groove "Timing" Belt pulleys which are positively engaged by the teeth of the belt. The other two (D & E) are flat pulleys, which are driven by the friction surface on the back of the belt. A small flat belt pulley idler (F) provides adjustment and more wrap around the four driven pulleys. These four pulleys, in turn, drive four specially molded U.S. Rubber rollers located on the other side of the plate. The rollers, by rotating, drive the hose (also made by U.S. Rubber) either in or out, as required.

*Manufactured by Simplon Corp., Dearborn, Mich.



"Grip" Powers is holding the "business end" of one of the most modern home appliances—a vacuum cleaner, built into the wall, with hose that extends or retracts *completely automatically.*

This cleaner can literally "put itself away," thanks to the U.S. PowerGrip "Timing"® Belt drive on the hose retraction mechanism (pictured above.) Because of PowerGrip's near-100% efficiency, the manufacturer was able to combine simplicity of design with exact response to constant changes in tension. This is just one of countless examples of this unique belt's ability to simplify and improve a power transmission unit.

These belts, plus expert engineering service, are obtainable at any of the 28 "U.S." District Sales Offices, at selected power transmission distributors, or by writing us at Rockefeller Center, New York 20, N. Y. In Canada, Dominion Rubber Co., Ltd.

Mechanical Goods Division

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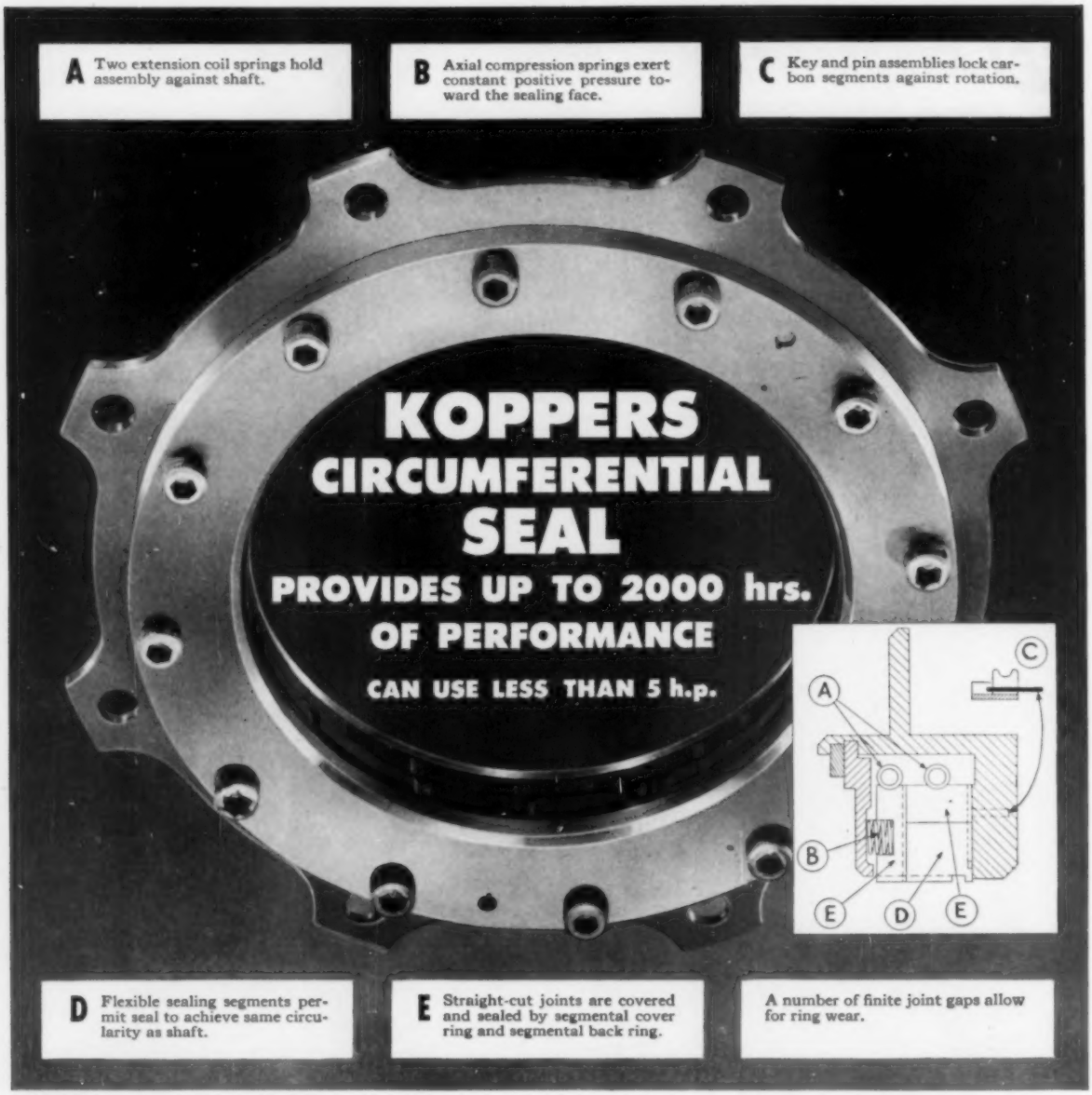
A Two extension coil springs hold assembly against shaft.
B Axial compression springs exert constant positive pressure toward the sealing face.
C Key and pin assemblies lock carbon segments against rotation.
KOPPERS
CIRCUMFERENTIAL
SEAL
PROVIDES UP TO 2000 hrs.
OF PERFORMANCE
CAN USE LESS THAN 5 h.p.
A
B
C
D
E
E
D Flexible sealing segments permit seal to achieve same circularity as shaft.
E Straight-cut joints are covered and sealed by segmental cover ring and segmental back ring.
A number of finite joint gaps allow for ring wear.

Koppers Circumferential Seal is a segmented carbon seal ring with straight-cut joints. Its design can be modified to use step type joints or step seal joints. Primarily a gas seal, the Koppers Circumferential Seal will seal liquids if the geometry of the shaft mating faces is changed.

Koppers Circumferential Seals are one of a large variety of seals designed and manufactured by Koppers for every industrial use. Because of this complete line, Koppers can recommend, without bias, the seal best suited to your specific application. And Koppers continuous development and testing of new designs and new materials assure you of the most advanced, most efficient seals for your purpose. If you have a sealing problem, write to the KOPPERS COMPANY, INC., Metal Products Division, Piston Ring and Seal Department, 7308 Scott St., Baltimore 3, Maryland.

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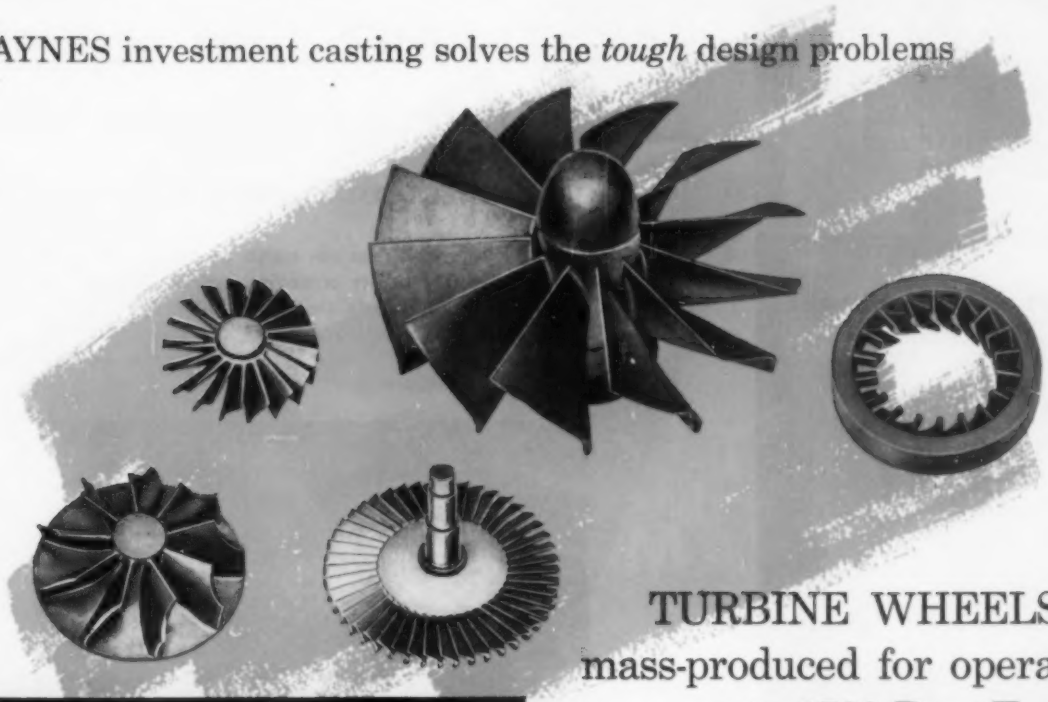
HAYNES investment casting solves the *tough* design problems



TURBINE WHEELS mass-produced for operation up to 1700 Deg. F

Special inspection equipment guarantees accuracy. Examinations by Gamma Ray (above) is one of a number of inspection methods used at Haynes Stellite Company's plant to insure top quality control.

Turbine wheels with intricate blading—some as thin as 0.020 in.—and ranging in diameter from 2 to 21 in. are now mass-produced economically by HAYNES' investment-casting method. The blades and wheel are produced as one integral part to close as-cast tolerances.

HAYNES' investment-casting method offers the design engineer a selection of alloys developed for economical operation over a wide temperature range—from room temperature to 1700 deg. F. The cast wheels have high strength and are capable of operating at speeds in excess of 42,000 revolutions per minute.

The freedom to select alloys for performance and to design for top efficiency is one of the big advantages of HAYNES' investment-casting process. For full details, write for the booklet "HAYNES' Investment-Casting." Address Haynes Stellite Company, Division of Union Carbide Corporation, General Offices and Works, Kokomo, Indiana.

HAYNES ALLOYS

HAYNES STELLITE COMPANY

Division of Union Carbide Corporation

UNION CARBIDE

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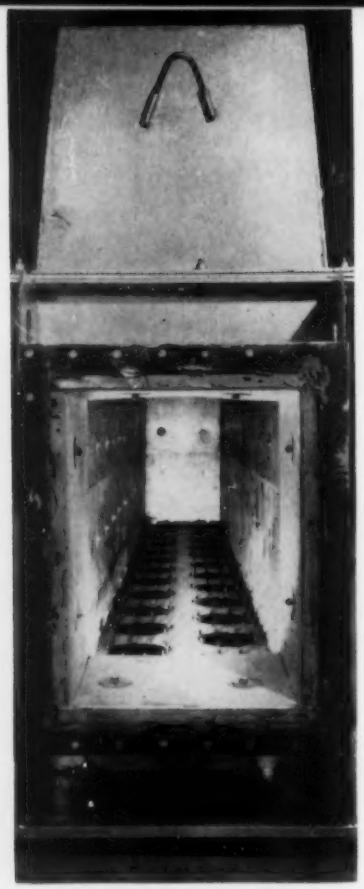
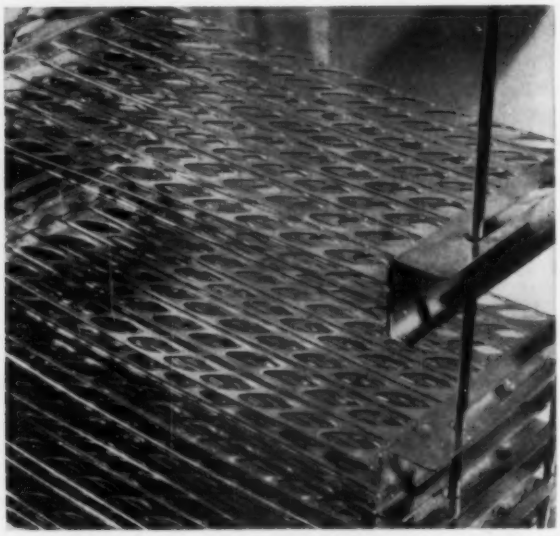
NOTHING can equal Stainless Steel

in its unique combination of properties

No other design material can match Stainless Steel in its combination of desirable properties: corrosion resistance, strength, hardness, beauty, cleanability and easy fabrication. For a reliable source of supply, United States Steel offers you the widest range of types, finishes and sizes. **Just call your steel warehouse.**



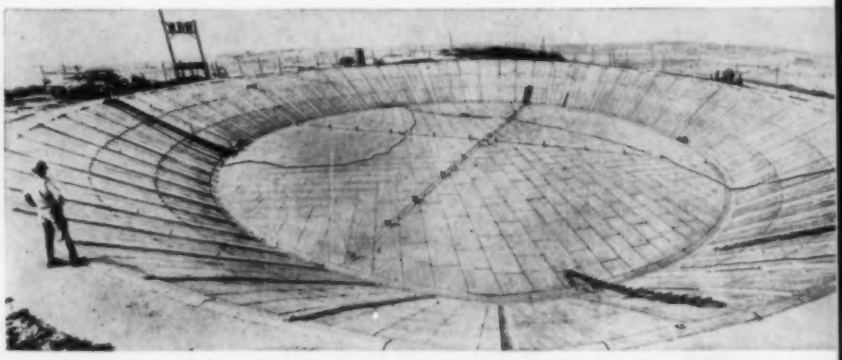
For High Temperatures. This recuperator is used on industrial furnaces. It uses waste flue gas to heat the incoming furnace air and thereby increase the efficiency of the furnace. Formerly, these recuperators were made with ceramic tubes, but heat transfer was low and leakage was high. The Hazen Engineering Company in Pittsburgh makes recuperators almost completely from Stainless Steel. Compared to ceramic designs, the Stainless design saves about 40% in fuel, increases furnace output about 10%-15%. The Stainless Steel performs well, even at this 1800-2300° F. temperature range.



For Cleanliness. When you work near nuclear radiation areas, you wear a small badge containing X-ray film that records how much radiation you have received. The film, "photodosimetric film," is developed in a Sensitometric Processing Unit made by Bar-Ray Products, Inc., in Brooklyn. The unit, including the trays shown here, is made completely from 18-gage Type 316 Stainless Steel because it resists corrosion, is easy to clean, has a hard, dense surface that doesn't harbor dirt.

United States Steel Corporation, Pittsburgh • American Steel & Wire Division, Cleveland
Columbia-Geneva Steel Division, San Francisco • National Tube Division, Pittsburgh
Tennessee Coal & Iron Division, Fairfield, Ala.
United States Steel Supply Division, Warehouse Distributors
United States Steel Export Company, New York

For Corrosion Resistance. The Hercules Powder Company needed an ammonium nitrate storage tank for their plant near Richmond, California. They took an old, World War I concrete reservoir and lined it with Type 304 USS Stainless Steel. The 14-gage sheets are laced with 18,000 feet of vacuum-tested welds. Tank holds two **million** gallons of solution, and is 200 feet in diameter at the top. U. S. Steel's Consolidated Western Division handled the complete installation.



USS STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS · PIPE · TUBES · WIRE · SPECIAL SECTIONS

UNITED STATES STEEL

THEY'RE NEW!

THEY CUT MAINTENANCE COSTS!

EATON DYNA-TORQ

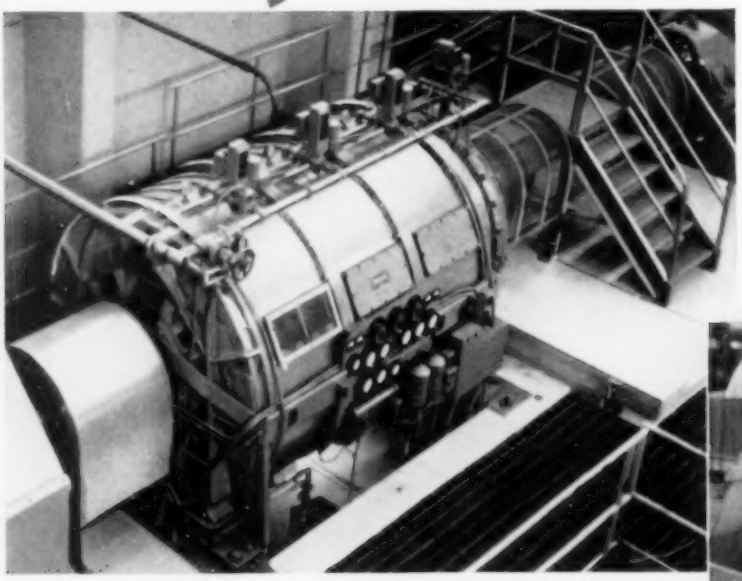
MAGNETIC-FRICTION CLUTCHES and BRAKES

FAST OPERATION • SELF ADJUSTING • EFFICIENT
SMOOTH, EASILY CONTROLLED ENGAGEMENT
WIDE RANGE OF SIZES AND CAPACITIES

Ask us for Illustrated Descriptive Literature

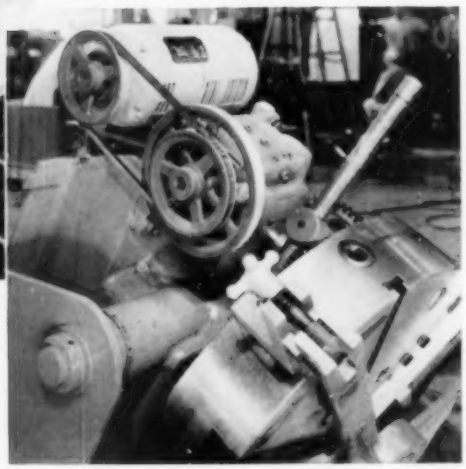
EATON *DYNAMATIC DIVISION*
MANUFACTURING COMPANY
3307 FOURTEENTH AVENUE • KENOSHA, WISCONSIN

20,000 H.P.



OR

¼ HORSEPOWER



EATON

DYNAMATIC®

Eddy-Current Equipment Can Solve Your Adjustable Speed Drive Problem

Write today for illustrated bulletins describing Dynamatic Eddy-Current Couplings and Drives—the modern method of speed control.

Need a big 20,000 horsepower drive? Or a compact, low-cost ¼ horsepower drive? For either requirement—or for any of the thousand-and-one applications between these extremes—Dynamatic Eddy-Current Drives, Couplings, and Brakes provide the ideal solution to difficult speed or torque control problems. Their efficiency and economy are being proven every day in every major industry—in both plant equipment and end product applications. Dynamatic equipment offers such important advantages as instantaneous response, infinitely adjustable speed control, wide speed range, quiet operation, low power loss, low maintenance costs, and adjustable speed from an AC power source.

EATON

DYNAMATIC DIVISION
MANUFACTURING COMPANY
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AT LAST! A SMALL WHITE-PRINTER THAT MAKES BIG PRINTS!

BRUNING

NEW! *Copyflex Model 300!*

Brings "Inside" Reproduction within the Means of the Smallest Engineering Firm or Department!
Now, with your low-cost, versatile Model 300, you can make high quality prints when you want them—rapidly, privately, and in any quantity. You can exercise complete control over valuable originals at all times.

Provides Large Companies an Economical Way to Supplement Main Reproduction Centers!
With its compact size, big printing width, and low cost, the Model 300 is an ideal helper for your big reproduction machine. Strategically located throughout your company, Model 300s can bring new speed, convenience, and efficiency to your reproduction operations.

Here it is! The compact, low-cost reproduction machine that offers all the versatility and big printing width of a large, expensive whiteprinter!

Just think—you can make sharp, black-on-white prints in seconds of a drawing or tracing up to 30 inches wide by any length. And anyone can operate the Model 300 after only brief instruction. One fingertip control turns the machine on or off, and regulates its speed. Exposure and development are automatically synchronized.

The new Copyflex Model 300 is ideal for drafting rooms and offices because it can operate anywhere without annoyance to personnel in the vicinity. It is clean, quiet, and odorless. No exhaust venting, plumbing, or accessory equipment required. It needs only a connection with a 115-volt AC outlet for operation.

If you're pressed by the boom in production for more and more engineering prints, the all-new Copyflex Model 300 is your answer! Its low initial cost combined with outstanding economy and convenience of operation and maintenance make it your soundest, low-cost investment of the year. Mail coupon today! You'll be glad you did!

BRUNING Copyflex

Best Process! Best Machines! Best Selection of Materials!

Offices in 37 Cities of the U.S. and Canada

CHARLES BRUNING COMPANY, INC., CHICAGO

In Canada: Charles Bruning Co. (Canada) Ltd., 105 Church St., Toronto 1, Ont.

CHARLES BRUNING CO., Dept. 83-O
4700 Montrose Ave., Chicago 41, Ill.

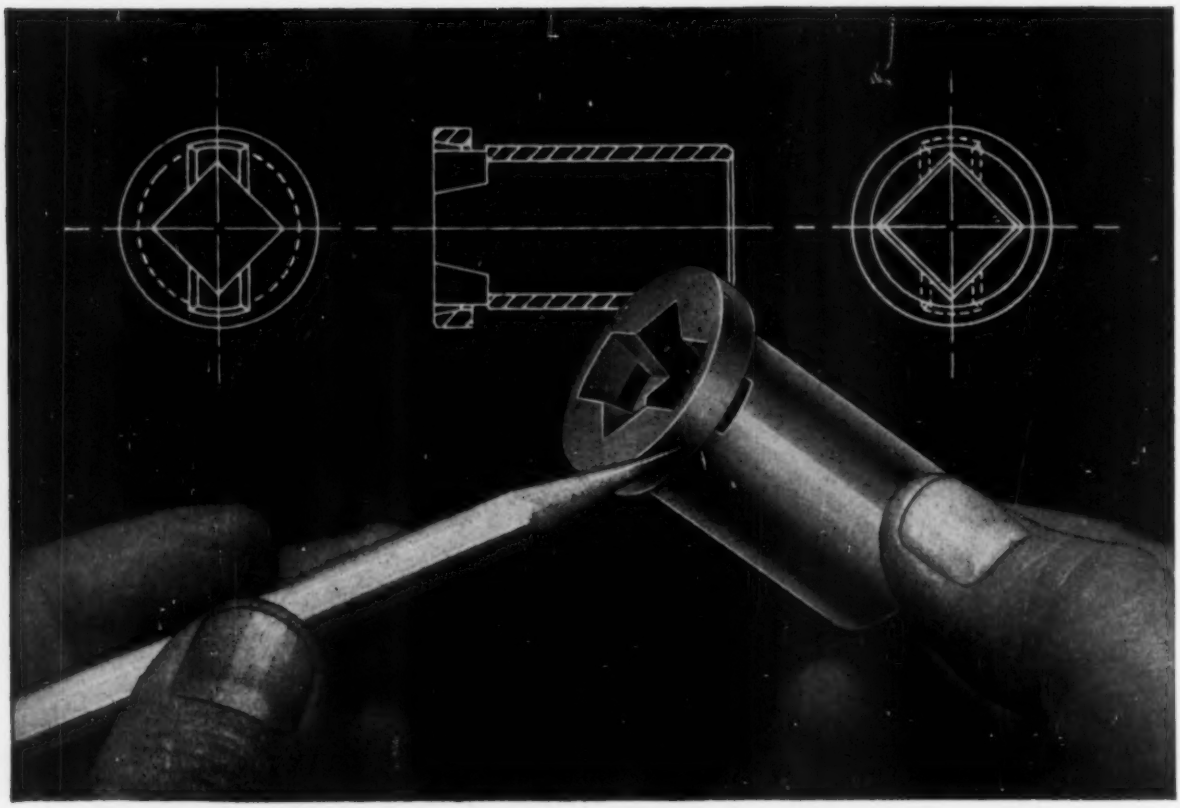
Please send me information on the all-new Copyflex Model 300.

Name _____ Title _____

Company _____

Address _____

City _____ County _____ State _____



How Would YOU Produce This Part With No Machining . . . No Scrap Metal?

PARKER SALES ENGINEERS

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Ollie J. Berger Company • 2039 East 72 Street

CINCINNATI 14, Ohio
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Daniel F. Marsh • 35 Chestnut Street

KIRKWOOD 22, Mo.
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Can't be done? Parker did it . . . sharp internal corners, lateral holes, chamfers, flanged end and all . . . by fast, low-cost powdered metal pressing and sintering. No subsequent machining . . . no scrap-metal loss. Just think of the savings compared with conventional machining methods.

In addition to these inherent cost savings, Parker-engineered Powdered Metal Parts offer a wide choice of tensiles, ductility, density, impact resistance and other physicals. Tooling-up is done quickly and at relatively low cost.

It will pay you to check on the economies and design possibilities of Parker-engineered Powdered Metal Parts. Just call the nearest sales engineer listed here or write the factory direct.

Parker White Metal Company • 2153 McKinley Ave., Erie, Pennsylvania

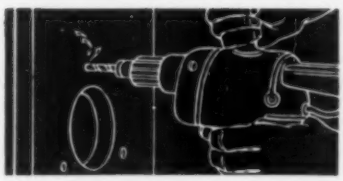
PARKER

high pressure ALUMINUM and ZINC die castings
POWDERED METAL PARTS

This Aetna Adapter Bearing is inexpensive, comes in a compact PACKAGE Unit . . . and talk about easy installation—

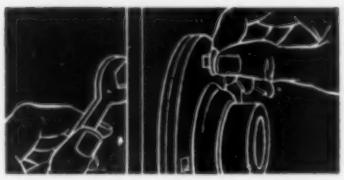
IT'S AS SIMPLE AS THIS:

A



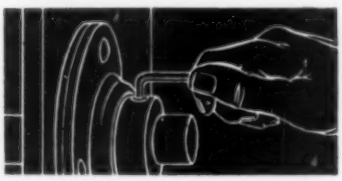
Drill (or punch) 3 bolt holes in shaft supporting member.

B



Place Adapter unit in position, insert bolts and tighten nuts.

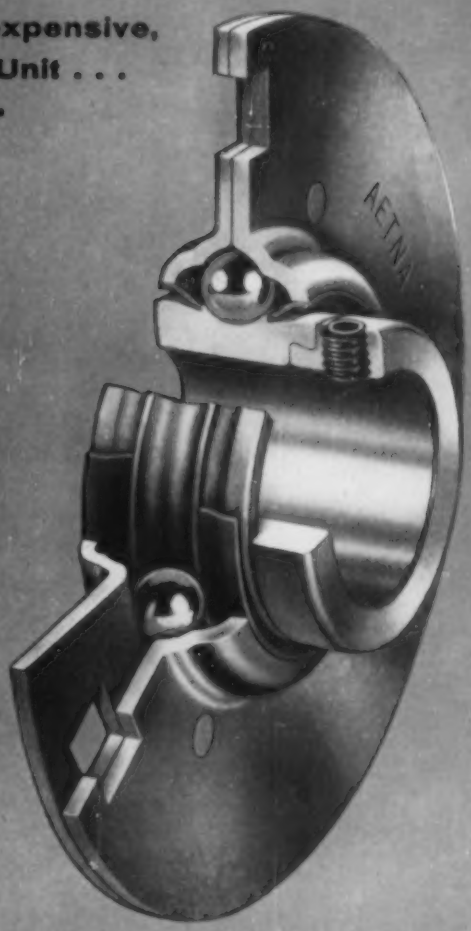
C



Install shaft, twist locking collar, tighten set screws.

And there you have it—

—all the advantages of ball bearing efficiency adapted to your current or projected equipment designs with minimum, or no engineering alterations.



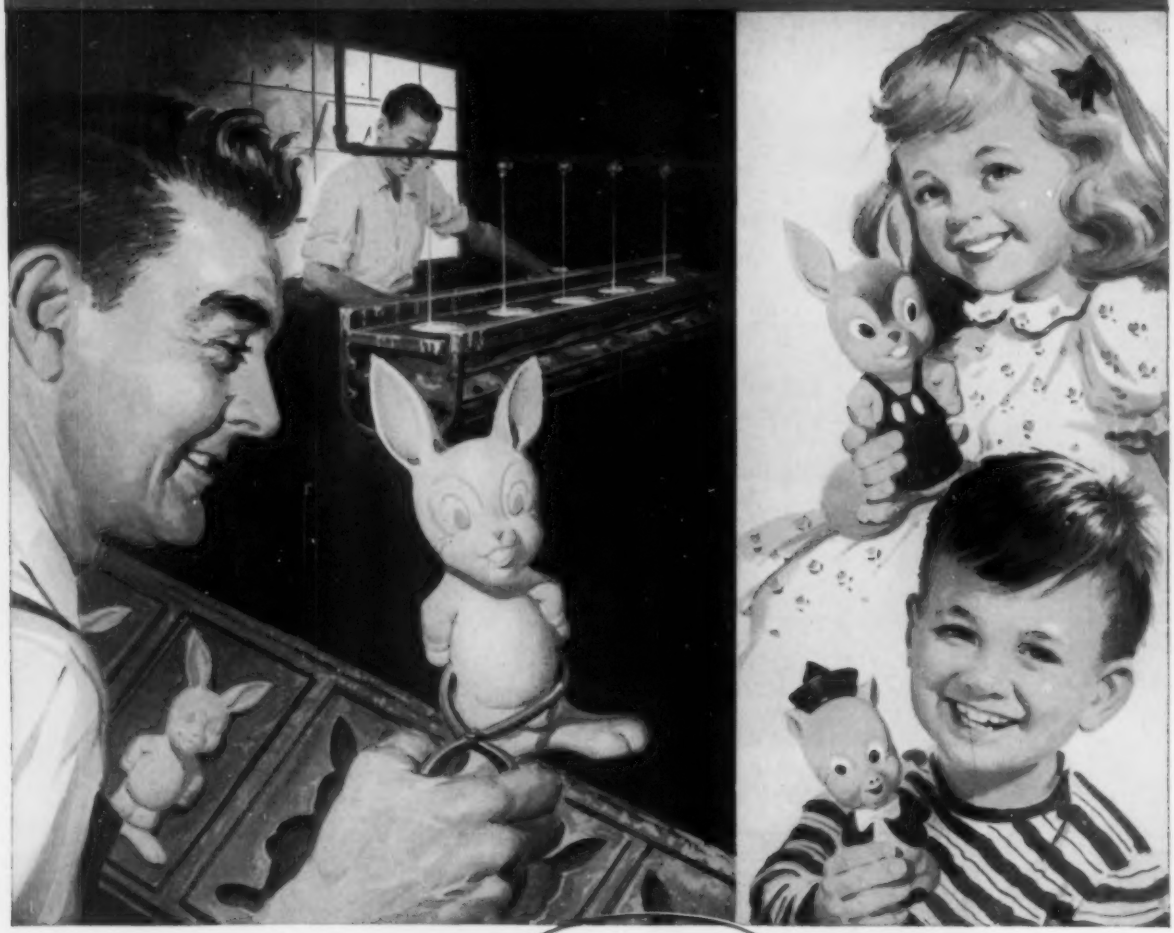
Designed and built-to-be-installed-and-forgotten this permanently lubricated, sealed-for-life Adapter bearing requires no re-lubrication, no maintenance of any kind. It combines self-aligning bearing, seals, mounting flange and locking collar in a single easy-to-handle package assembly that mounts wherever shafts can be supported—including sheet metal or any semi-rigid structural members. Available in a range of standard shaft sizes. Write us or call in our local expert, your nearby Aetna distributor.

AETNA BALL AND ROLLER BEARING COMPANY

DIVISION OF PARKERSBURGH-AETNA CORPORATION • 4600 SCHUBERT AVE. • CHICAGO 39, ILL.

Aetna Anti-friction Consultant to Leading Original Equipment Manufacturers since 1916

THIS RESIN MAKES PLASTISOL MOLDING TOYS CHILD'S PLAY



Exon 654 ... specifically for (trouble-free) plastisols

... typical of the Pin-Pointed Properties in Exon Vinyl resins

Slush molders, such as toy manufacturers, find plastisols formulated from Firestone Exon 654 unsurpassed for processing ease.

These plastisols offer excellent viscosity, stability and flow properties. They fuse quickly. And plastisols made from Exon 654 always coat the mold smoothly and evenly.

Exon 654 needs no grinding. It is a stir-in type plastisol resin expressly created to impart excellent heat and light stability, paste viscosity stability, physical toughness and chemical stability to your final products. No wonder toy manufacturers, as other companies who use plastisol molding, specify Exon 654.

Another example of how Exon's Pin-Pointed Properties match your particular needs.

Exon 654 is just one of the many fine resins in industry's most complete line of versatile vinyls. It is another reason why industry looks to Firestone Exon for engineered answers to its needs.

Consider your own production or product problems. Then, for resin properties pin-pointed to the best answer for you, check with Firestone.

Firestone

EXON

RESINS

For complete information and technical service, call or write:

CHEMICAL SALES DIVISION: FIRESTONE PLASTICS COMPANY

DEPT. 76K, POTTSTOWN, PA. • A DIVISION OF THE FIRESTONE TIRE & RUBBER CO.

IN CANADA, CONTACT CHEMICAL SALES DIVISION, FIRESTONE TIRE AND RUBBER COMPANY OF CANADA LTD., HAMILTON, ONT.

INDUSTRY'S MOST COMPLETE LINE OF VINYLS ENGINEERED TO YOUR SPECIFIC NEEDS

Spring steel within this range...

FOR THE MOST EXACTING NEEDS KNOWN TODAY!

• That this is the age of specialization is certainly true in the use of steels. And in this regard *Athenia Steel* customers benefit especially by two not-too-common factors. First, by extreme control of quality and uniformity, unsurpassed, seldom equalled *anywhere!* Secondly, by painstaking technical service to determine or develop precisely the right steel for any special need.

Here at Athenia we concentrate on cold rolled high carbon flat steels, custom made of .45 carbon and higher, in widths from .015″ to 16″ and thicknesses from .001″ to .065″. Full range of finishes and tempers. We also produce special narrow width stainless, and the new super-tough, corrosion resistant spring material, Nilcor*.

For a new and profitable experience in service and in steel controlled precisely to *your* needs . . . try us!

*Trade Mark National-Standard Company

NATIONAL-STANDARD COMPANY • NILES, MICHIGAN
Tire Wire, Stainless, Fabricated Braids and Tape

NATIONAL STANDARD

DIVISIONS: NATIONAL-STANDARD, Niles, Mich.; *tire wire, stainless, music spring and plated wires* • WORCESTER WIRE WORKS, Worcester, Mass.; *high and low carbon specialty wires*
WAGNER LITHO MACHINERY, Secaucus, N. J.; *metal decorating equipment* • ATHENIA STEEL, Clifton, N. J.; *flat, high carbon spring steels* • REYNOLDS WIRE, Dixon, Ill.; *industrial wire cloth*

MORE EFFICIENT DESIGN, IMPORTANT SAVINGS, SIMPLIFIED ASSEMBLY, BETTER APPEARANCE

These are some of the many benefits reported by Design Engineers who have adopted TRU-LAY PUSH-PULLS for remote control operations on literally hundreds of products

Here are typical comments recently received from equipment manufacturers whose machines or implements are equipped with these accurate and dependable remote controls:

Saves Time, Labor and Material
"The use of your flexible Push-Pulls saves us a great deal of time, labor and material. The old linkages frequently required much planning in both engineering and shop which is not required now. On some of our equipment we use Push-Pulls from 10 to 30 feet in length. They operate clutch controls on the Main Power Unit, Feed Conveyors and Delivery Conveyors."

Greater Flexibility of Design
"The principal advantage of Tru-Lay Push-Pulls in our application is that they permit flexibility in locating the control valve in relation to the operator's position."

Cost Less to Install
"Tru-Lay Push-Pulls are easier and less expensive to install than linkages for remote control of power take-off, brake and clutch. Better appearance, too."

Simple and Neat
"For several models of farm tractors, we selected your controls for their simplicity and neatness of application as governor controls."

Solution to Tough Problem
"Can be installed where straight rods are impossible . . . for Remote Control of transmissions, brakes and clutches."

Eliminates Maintenance
"Simple operation and elimination of maintenance problem are the major advantages in using your Push-Pulls."

Reduces Number of Parts
"Your Push-Pulls have eliminated links, radius rods and other lost-motion devices for remote control of hydraulic valves."

Provide ACCURATE Control
"Tru-Lay Push-Pull control cables provide minimum back-lash, even in installations up to 30 feet in length, because the cable is designed to close tolerances with minimum drag and lost motion."

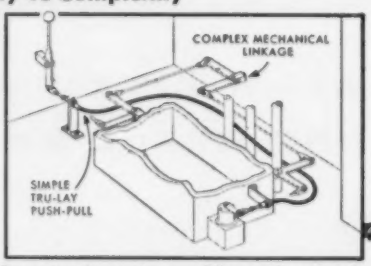
• • •

TRU-LAY PUSH-PULLS are "Solid as a rod but *Flexible* as a wire rope." This flexibility makes it possible to snake around obstructions . . . permits the ideal arrangement of all elements of remote controls.

***Advantages** of Tru-Lay Push-Pull flexibility and simplicity are pictured below—*

Simplicity vs Complexity

Compare the TRU-LAY PUSH-PULL cable in illustration with the mechanical linkage. PUSH-PULLS are simple, have but one moving part, are noiseless and give lifetime service accuracy. Linkages are complex, made of many parts; they wear at many points. Their use brings increased backlash, lost accuracy and vibration rattles.



Construction Equipment and **Farm Implements** provide good examples of the wide-spread use of these accurate, simple and dependable Push-Pulls. On Power Shovels, Winches, Graders, Road Oilers, Dump Trucks, Snow Plows, Engine-driven Pumps, Crushers, Tractors, Combines, Corn Pickers, Corn Row Sprayers, Corn Detasslers, Orchard Sprayers, Power-driven Tree Trimmers, Tobacco Picking Machines and others . . .

TRU-LAY PUSH-PULLS are operating unfailingly for the remote control of Hydraulic and Air Valves, Brakes, Clutches, Transmissions, Throttles, Chokes, Governors, Power Take-Offs, Spray Nozzles, Vent Directional Fins and on many other applications.

ACCO *Our DATA FILE will answer all further questions*

AUTOMOTIVE and AIRCRAFT DIVISION
AMERICAN CHAIN & CABLE

601-E Stephenson Bldg., Detroit 2
2216-E South Garfield Ave., Los Angeles 22 • 929-E Connecticut Ave., Bridgeport 2, Conn

TRADE MARK

There is No Worry about Failures or Maintenance Costs with TRU-LAY Push-Pull Remote Controls

Long Life is a matter of record. We have never heard of a Tru-Lay Flexible Push-Pull Control wearing out in normal service. Failures, that sometimes harass users of more complex controls, are eliminated by the use of these simple, positive-action controls.

Dependable Operation of these controls is a certainty, even under the most adverse conditions . . . HOT as jet engines (note: Tru-Lay Push-Pulls are actually performing on hot jet applications) . . . COLD to 70° F below zero . . . SOAKIN' WET . . . ABRASIVE . . . or just plain TOUGH.

Freedom from Trouble is assured because of such features as . . . full protection of the inner, working member by the tough flexible conduit . . . lubrication of the inner, working member *for life* during assembly . . . seals that keep moisture, dust and other foreign matter out of the unit . . . cold swaging of fittings that makes them integral parts of the control unit.

Accuracy is inherent in the basic design of Tru-Lay Push-Pulls. They are precision products, not gadgets.

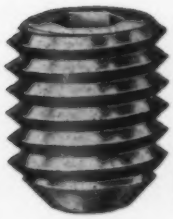
Capacity ranges from light jobs up to jobs of 1,000 lbs. input. These Push-Pulls will handle jobs 150 feet or more from the control point.

"Solid as a rod, Flexible as a wire rope" aptly describes Tru-Lay Push-Pull Controls. This flexibility provides positive, remote action whether anchorages are fixed or movable . . . it damps out noise and vibration . . . it greatly simplifies installation of controls by reducing the number of working parts and by making it possible to snake around obstructions.

Adaptability to all sorts of mechanical situations explains, in large measure, the wide-spread application of Tru-Lay Push-Pulls. Standard anchorages, fittings and heads have been designed that meet requirements on approximately 80% of the installations. Simple modifications of these standards, or minor changes in your own design, cover almost every special situation. Our engineers have the know-how on such matters, and will work with you.

For Further Information—The DATA FILE pictured at the left contains six booklets and bulletins that will answer any further questions you may have about this versatile and dependable tool. It is quite likely that this material will point the way to a simplified solution of your remote control design problems. Write for a copy.

how to keep costs down



...profit margins up!

ALLEN Engineers will show you how you can save time and money by using standard* ALLEN Hex-Socket Cap and Set Screws instead of specials.

Let's get this straight right away... if your product design MUST have special cap or set screws, then ALLEN's the place to come for them.

But our engineers have found, from a good many years of experience, that designs frequently call for *special* hex-socket cap and set screws that are only slightly "off-standard." These specials take longer to get, cost more.

Allen engineers can probably save *you* both time and money by working with you on ways to use *standard* Allen Hex-Socket Cap and Set Screws, where specials may seem to be necessary. Just send blue prints, or good descriptions, of your product designs to our Engineering Department, or talk with your Allen Field Representative.

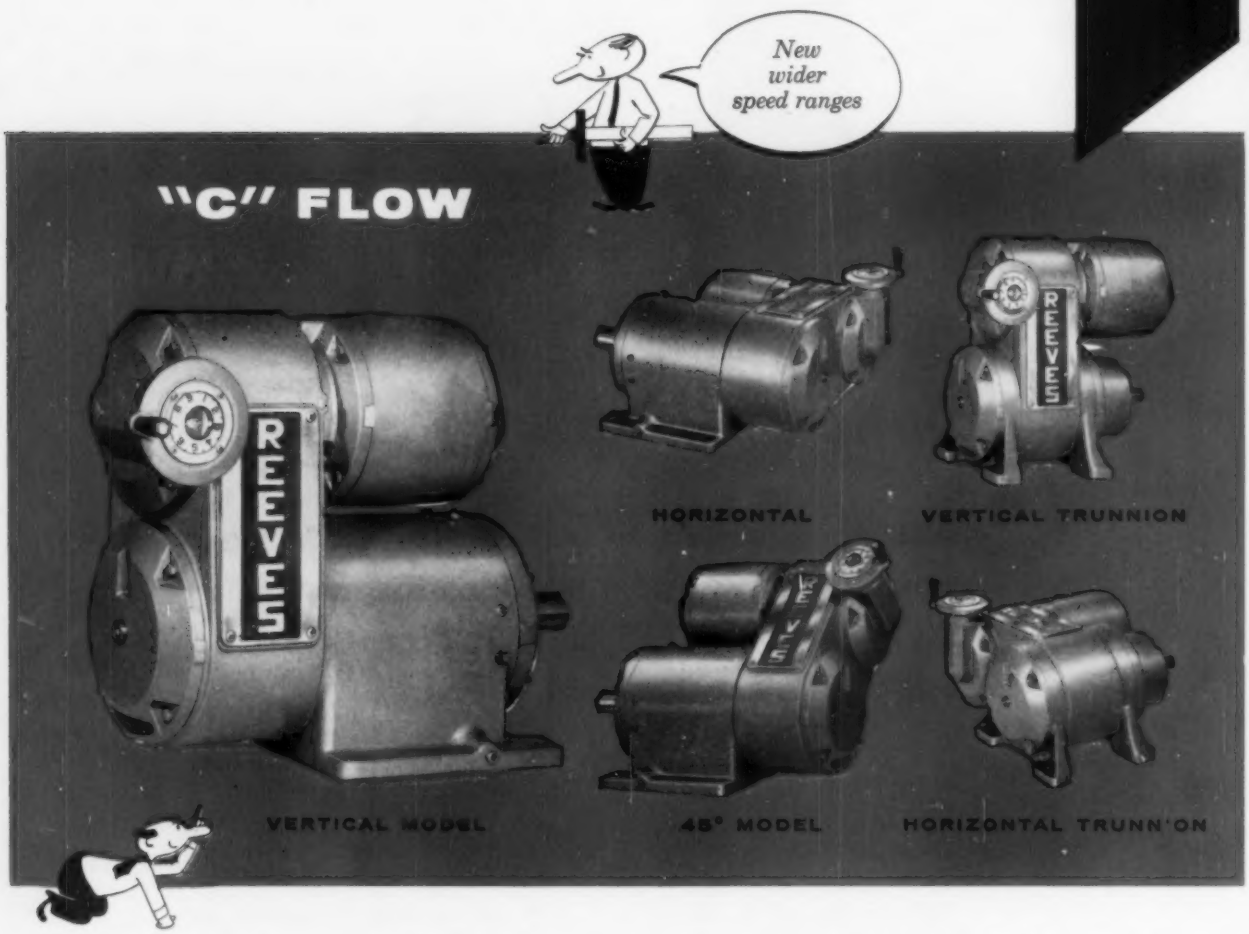
*ALLEN **manufactures 1457 *standard* items**

Stocked and sold by leading industrial distributors everywhere

ALLEN MANUFACTURING COMPANY
Hartford 2, Connecticut, U.S.A.

ALLEN HEX-SOCKET SCREWS HEAD

variable speed with new versatility and performance



A triumph of new Motodrive design . . . inside and out

New REEVES Vari-Speed Motodrives, sizes 200 and 300, are complete variable speed power packages, built with compactness and precision, to give improved performance on installations 1 through 5 hp.

The new sizes are designed in two styles—"C" flow and "Z" flow. In each style, there are several different models and reducers with increased capacity in single, double or triple stages.

The flexible design permits hundreds of combinations . . . space-saving, space-fitting *standard* assemblies to meet most installation requirements.

The handwheel control location can be rotated to optional positions for greater operating convenience; extra precision of control is available with the addition of one or more REEVES accessories or modifications.

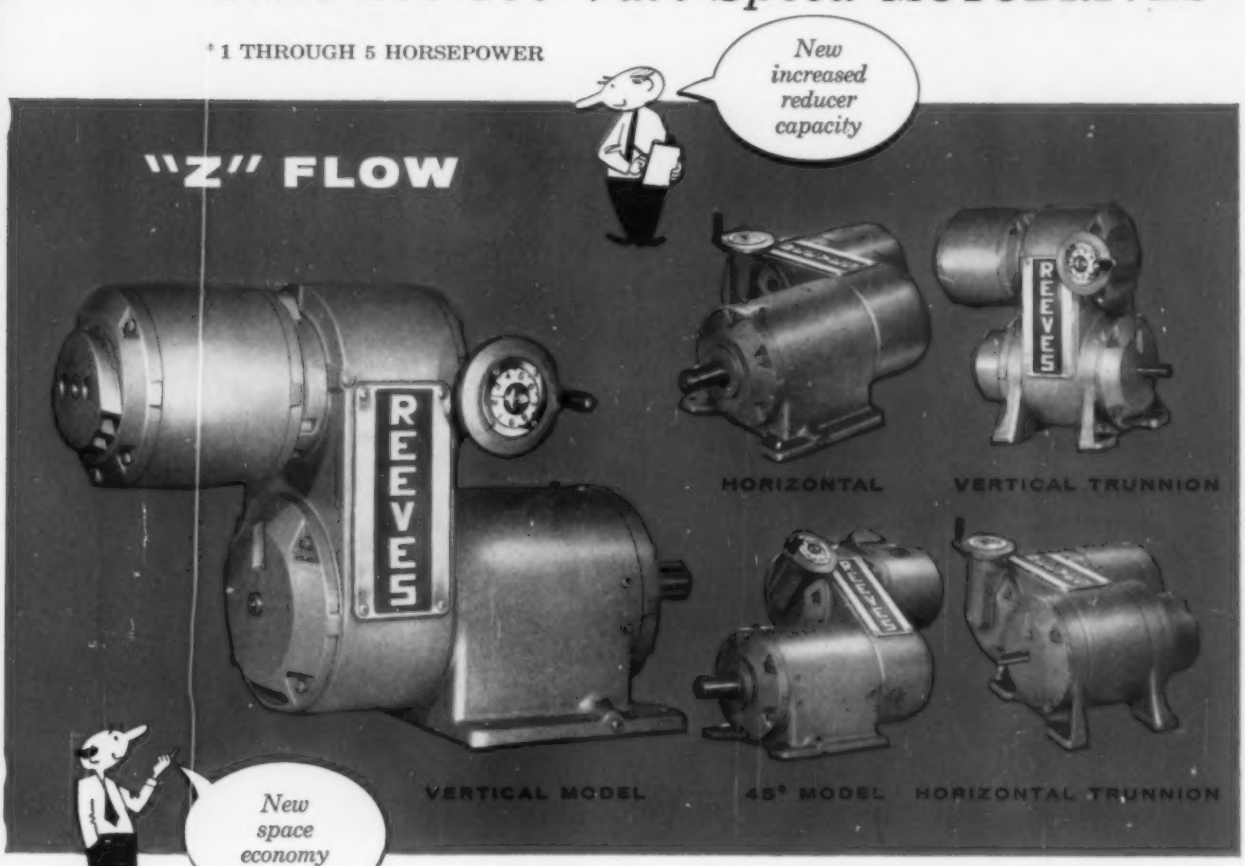
Refinements to the time-tested REEVES

NEW

REEVES®

*Sizes 200-300 Vari-Speed MOTODRIVES**

* 1 THROUGH 5 HORSEPOWER



operating principle now assure even longer trouble-free service.

New disc assemblies permit wider output speed ranges . . . discs are pre-aligned . . . pre-loaded spring maintains correct belt tension for longer belt wear . . . *exclusive* "close-grooving" lubrication assures free sliding discs . . . new Metermatic system automatically lubricates the motor and variable shaft bearings.

Sizes 200 and 300 are versatile, hard-working new models in the full line of REEVES Motodrives which provide instant and accurate variable speed control on ¼ through 40 hp. applications.

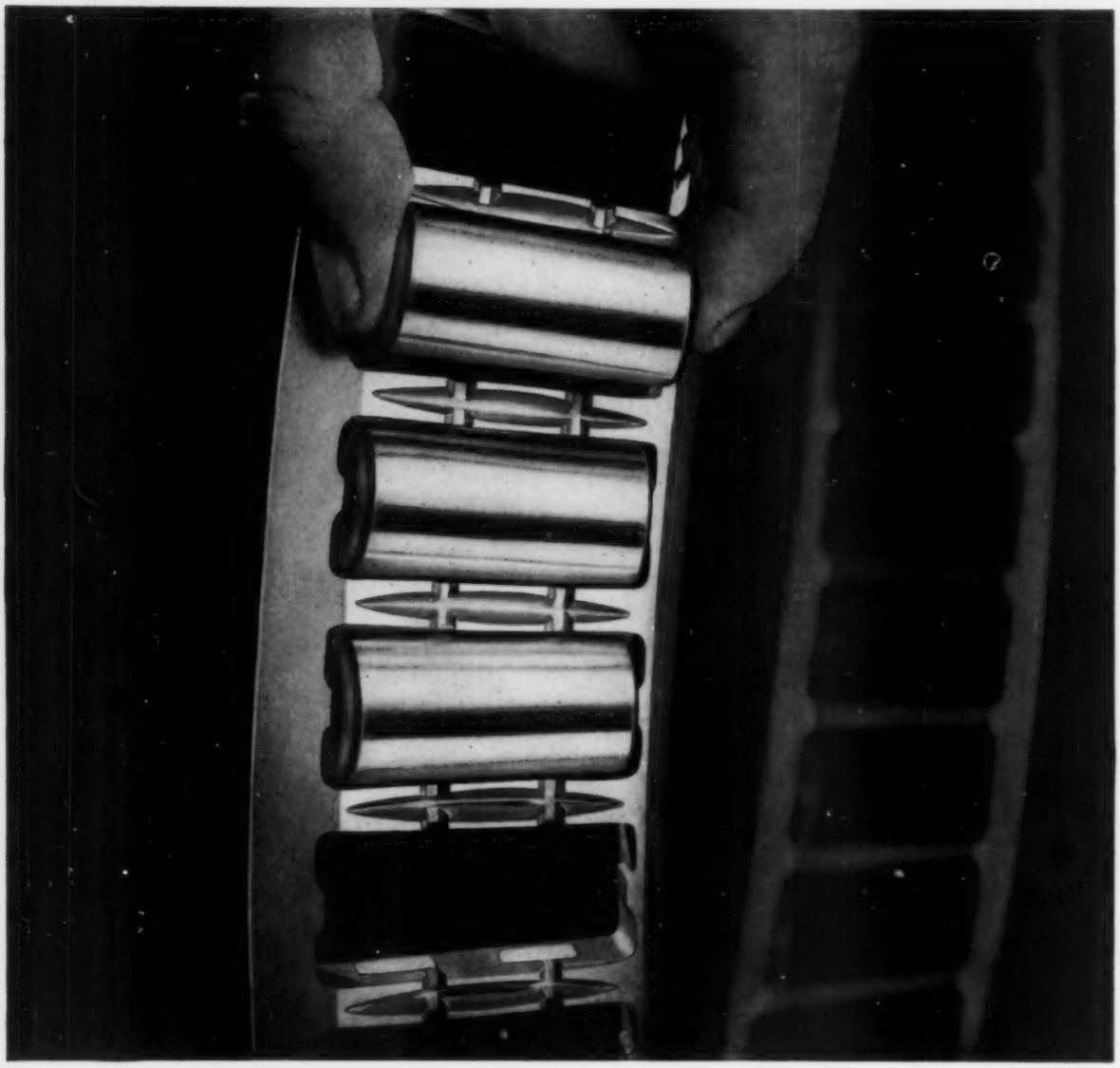
Complete details, dimensions, illustrations and prices on assemblies, modifications and accessories are in Catalog K31a-M571. Write for your free copy today.

REEVES PULLEY COMPANY

Division of **RELIANCE** ELECTRIC AND ENGINEERING CO.

Columbus, Indiana

TORRINGTON *TAPERED ROLLER* BEARINGS



Accurately caged . . . to cut your costs!

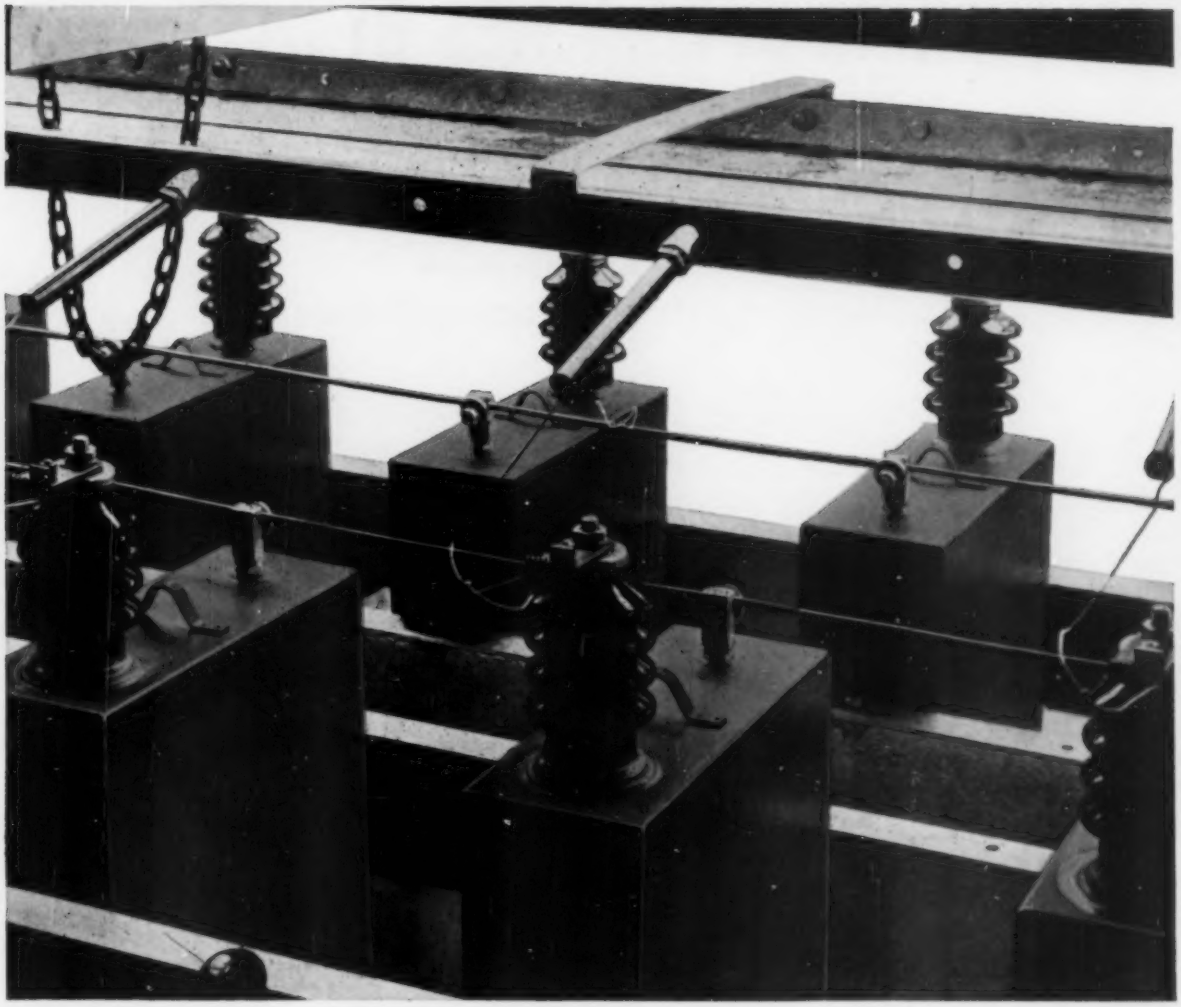
The one-piece, cast-bronze cage you see above is one of the reasons why TORRINGTON Roller Bearings give long, low-cost service. Note the individual roller retainment, for example. This helps keep the rollers thoroughly lubricated at all times. Race surface inspection is simplified. The machined pads in each roller pocket make sure the rollers are guided accurately at the pitch line. All this to minimize wear . . . lengthen bearing life.

Yes, TORRINGTON Roller Bearings cut your costs. They're made of the finest bearing quality steel available, heat treated by the most modern methods. No wonder they're so rugged . . . so dependable. Specify TORRINGTON *Tapered* or *Cylindrical* Roller Bearings for heavy loads and low maintenance.

THE TORRINGTON COMPANY
South Bend 21, Ind. • Torrington, Conn.
District offices and distributors in principal cities of United States and Canada

TORRINGTON BEARINGS

Spherical Roller • Tapered Roller • Cylindrical Roller
Needle • Ball • Needle Rollers



These Tobe Deutschmann Corporation capacitors are protected by a stainless steel case. Carbon steel cases could not withstand for long this type all-weather service.

Sealed in stainless, these capacitors laugh at city smog or rugged weather

Operating outdoors in all kinds of climate, these capacitors are attacked by salt spray, fog, industrial fumes and smoke particles. Their galvanized steel casings required cleaning and painting every two or three years. But, hermetically sealed in all-stainless steel cases, these capacitors now require no maintenance whatsoever.

Reason? Stainless stands up where ordinary steels fail. It fights corrosion, heat, wear and abrasion. What's more Crucible stainless steel can be readily fabricated by normal shop methods. Why not let your nearby Crucible representative show you how stainless can help improve *your* products? *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

Canadian Distributor—Railway & Power Engineering Corp., Ltd.

FASTENING SPECIALTIES BY *National*

Get more dependable holding
power for better product assembly with these
National SPECIALTY FASTENERS!

Lok-Thred® Bolts, Studs, Screws—Seal and lock against involuntary loosening... Lok-Thred re-forms the metal of the receiving thread under high compressive stresses into intimate contact with itself, eliminating all voids. Yet, it's fully re-usable. Requires no selective fits. Can be used with ordinary tools. Available in all sizes of bolts, studs, screws... No. 6 or larger.

Spin-Lock® Fasteners—Give you strength at low cost, with self-locking, ratchet-tooth action... Spin-Lock machine and tapping screws have angled teeth to permit fast, easy tightening. They require about 20% greater torque to loosen. Available in pan, truss, flat and hex heads; slotted or Phillips recessed heads; No. 4 to $\frac{3}{8}$" diameters, lengths from twice diameter and up.

Thread Cutting Screws—For joining metals or plastics without tapping... Use wherever it is desirable to remove rather than displace thread material. Four types: 1, 23, 25, and F cover most applications. Phillips or slotted heads, all styles, all sizes. Also type A and B tapping screws for fastening light sheet steel or light gauges of other metals.

Lock Nuts—Three types, to meet every requirement... 1. *Huglock*, for locking without seating and under adverse conditions. 2. *Marsden*, free-running until seated... for minimum-cost locking. 3. *Drake*, a two-piece design for use under severe stresses, shock, vibration. All types are all-metal, fully re-usable without loss of positive locking action.

Welding Fasteners and Weldnuts—Provide trouble-free assembly of fabricated metal parts... Use National welding fasteners when primary fasteners must be cleanly welded into exact position. National's complete line of projection welding screws and nuts is available in stock sizes, for optimum welds in materials .030 to $\frac{1}{4}$" thick. We will develop special designs for you.

Flex-Head® Locking Screws—Self-locking, highly resistant to fatigue, shock, impact... Tight locking results from flexing of the head and axial spring tension produced when fully torqued against a rigid seat. Flex-Head screws are identical in dimension, and interchangeable with standard machine screws. Made of 1022 steel and heat-treated for top strength.

Tuff-Tite® Cushioned Fasteners—Seal openings, eliminate vibration noises, absorb shock... Pre-assembled neoprene washers also prevent finish marring! Available as tapping screws, thread cutting screws, machine screws, roofing bolts, stove bolts, or wood screws; with Phillips or slotted heads; pan, round, truss or hex head styles.

Place® Bolts—Self-locking...resist impact, shock and fatigue failure by controlled spring action of reinforced, diaphragm head... Place bolts resist involuntary loosening when rigidly seated. Typical uses: connecting rod bolts, main bearing cap screws, flywheel bolts. Available in high carbon or alloy steel, in a wide range of sizes.

Save yourself time and trouble in searching for the right fastener. Make National your *one source* for standards, specialties and special designs. Our standard line includes all types and sizes... nuts, cap and set screws, machine bolts, carriage, step and elevator bolts, plow bolts; Phillips recessed head, or slotted, Sems, machine screws, wood screws; stove bolts, pipe plugs, cotter pins and rivets.

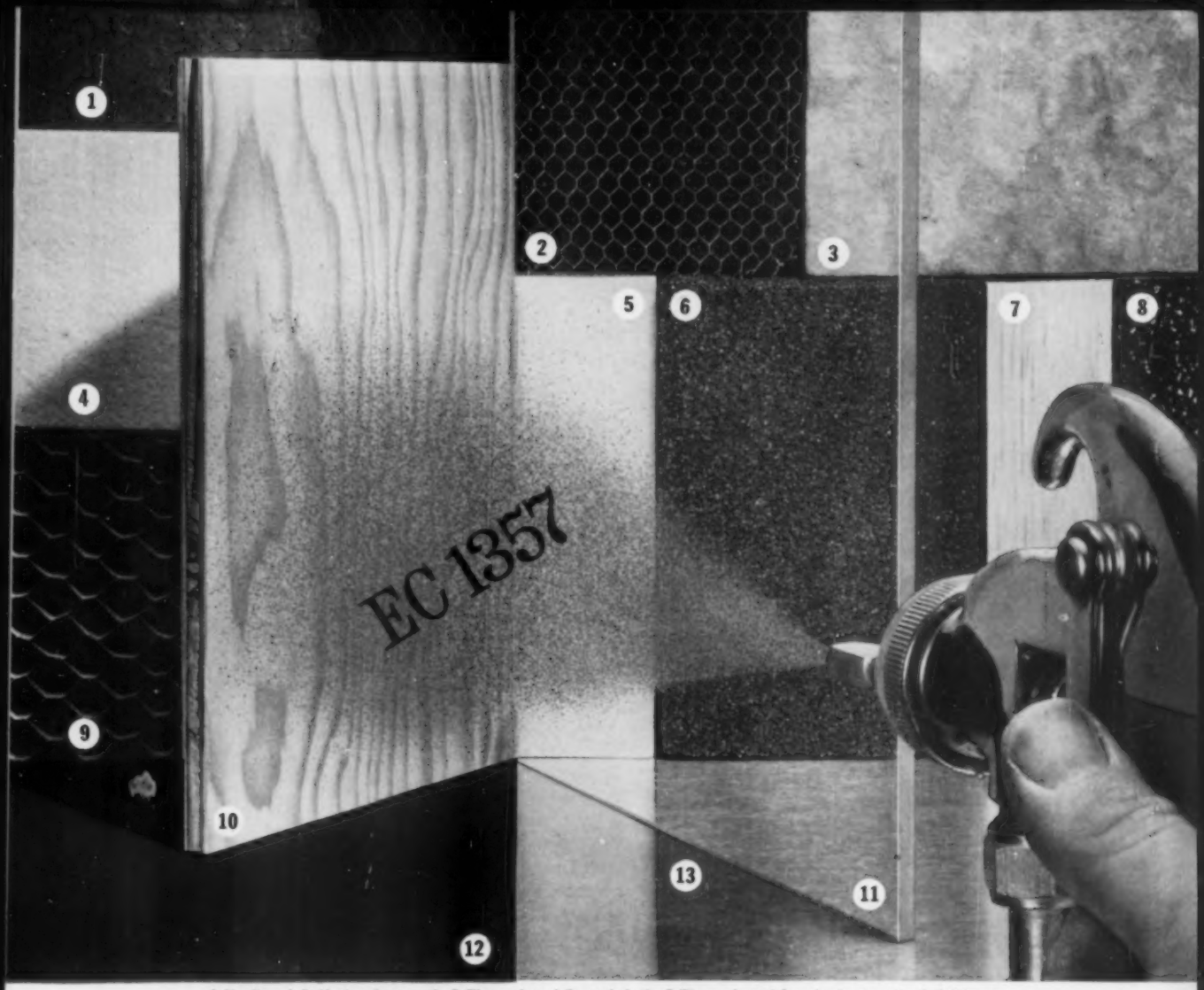
National can supply any nonstandard fastener, or design and produce specials for you. Write for National's *Special Products* booklet, or for information on the fastening specialty that interests you.

THE NATIONAL SCREW & MFG. CO. • CLEVELAND 4, OHIO

***Pacific Coast:* National Screw & Mfg. Co. of Cal. • 3423 South Garfield Ave., Los Angeles 22, Cal.**

National PRODUCTS

Fasteners **Hodell Chains** **Chester Hoists**



1. Hardboard 2. Aluminum honeycomb 3. Fibrous glass 4. Foamed plastic 5. Fibrous glass reinforced polyester resin 6. Cellular glass 7. Balsa wood 8. Porcelainized steel 9. Paper honeycomb 10. Plywood 11. Glass 12. Porcelainized aluminum 13. High-pressure laminate

3M Adhesive EC-1357

. . . just one adhesive bonds all kinds of sandwich materials!

You name the core and skin materials . . . just one versatile adhesive, EC-1357, will make non-load-bearing sandwich panels of them all!

For instance, cores of cellular or fibrous glass, wood, honeycombs of aluminum, paper or steel; skins of steel, plywood, glass, porcelainized metal, hardboard, aluminum, to name a few.

The union you get has great strength which increases as production continues, and resists moisture, high and low temperatures, weathering. For maximum immediate bond strength, EC-1357 may be force-dried through infrared exposure; or it can be dried at room temperature. All you need is a nip roller or cold press to bond sprayed surfaces. You save time and money. For load-bearing uses, look into 3M Adhesive EC-1177.

SEE WHAT EC-1357 BY 3M CAN DO FOR YOU! Consult 3M research. Contact your 3M Field Engineer. Or for information and free literature, write on your company letterhead to: 3M, Dept. 78, 417 Piquette Ave., Detroit 2, Michigan.

PRODUCT OF 3M COMPANY RESEARCH

MINNESOTA MINING AND MANUFACTURING COMPANY • ADHESIVES AND COATINGS DIVISION

417 PIQUETTE AVE., DETROIT 2, MICH. • GENERAL SALES OFFICES: ST. PAUL 6, MINN. • EXPORT: 99 PARK AVE., NEW YORK 16, N.Y. • CANADA: P.O. BOX 757, LONDON, ONT.

Thelco vacuum oven has shelves of nickel-plated expanded metal.

Inside this vacuum oven...

functional, durable, expanded metal at work

Thelco incubator with doors opened, showing expanded metal shelves. A product of Precision Scientific Company, Chicago, Illinois.

When the shelving you are using has to stand up under heat and heavy use, and must also provide free circulation of air—that's the time to call for Penmetal expanded metal.

Here's a case in point: Precision Scientific Company, the manufacturer of Thelco laboratory ovens and incubators, puts durability into shelving by making it out of nickel-plated Penmetal expanded metal. Shelving stays bright and clean through many years of service. It's exceedingly strong and weighs next to nothing. What's more, heated air can circulate freely, thanks to the open mesh, and the shelves are inexpensive to fabricate.

Functional, durable shelving—still another example of the versatility of expanded metal. Actually, it has thousands of uses. In fact, there's a fine chance its application can improve your product.

Send for descriptive booklet which includes mesh sizes, weights and dimensions. Ask for catalog 509-EM.

PENN METAL COMPANY, INC.

General Sales Office: 40 Central Street, Boston 9, Mass.
Plant: Parkersburg, W. Va.
District Sales Offices: Boston, New York, Philadelphia, Pittsburgh, Detroit, St. Louis, Dallas, Little Rock, Seattle, San Francisco, Los Angeles, Parkersburg

Penmetal

a name to remember

PM-153

Progress Report:

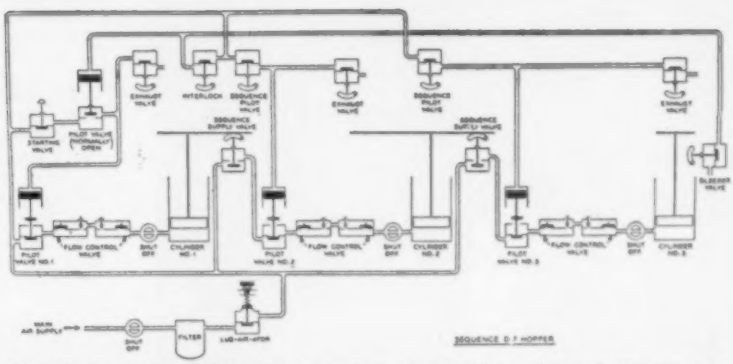
SCHRADER AIR PRODUCTS PERFORM JOBS IN SEQUENCE—AUTOMATICALLY

• Don't send a boy to do a man's job

When you say that, smile, if you're talking about air. Air can do *more* than a man's job. It can perform complicated, time-consuming operations faster, more accurately, and much more economically than *any* man.

There was a time when air power was used for nothing but simple one-shot actions, but those days are far behind. Now, automation has brought air so far beyond the "bellows-in-the-forge" age that the contrast is startling.

Manufacturers who think of Schrader Air Products only for the so-called simple-minded jobs are missing out on one of the true revolutions of our times. Their competition is using air systems, on the other hand, to make precision operations to close tolerances, for operations in sequence, and you can't blame them if they're a little smug about the amazing effectiveness, economy, and safety they've developed.



Schematic shows how a Schrader air system operates for plated part dippers, shortening the cycle, and releasing operators for more useful jobs.

FOR EXAMPLE:

• This job was driving sane men off their rockers

Until recently, the toughest job at a New Haven plating company was dipping baskets of plated parts in three successive baths. The triple bath sequence was not just monotonous—it was slow, expensive, in a corrosive atmosphere, and calculated to frazzle the tempers of workers. Then the operation was automated with Schrader Air Products. The dip hoppers now operate as if by magic—in solitary splendor. Completion of one sequence automatically starts another.

The schematic on this page is eloquent. Combinations of Schrader cylinders, pilot valves, two way valves, and flow control valves have been engineered into a true automated sequence system. Once again, open-minded engineers discovered the best way—air—had definite advantages.

• What you don't know can hurt you

Most engineers already know that Schrader Air Products are available NOW, that the products are designed to be fitted together as simply as an Erector set, and that the hundreds of different parts available offer capabilities that are virtually limitless. Advantages? Well, here they are again: Exceptional economy is basic. Safety margins can be widened by the use of special control techniques. Simplicity of air systems allows fingertip-push-button-tiptoe operations that are fatigueless. Production is speeded up.

• Take a good look at yourself

Better yet, let *us* look you over. Schrader engineers will be happy to assist you in planning for the most efficient use of air in your plant. And they'll be glad to recommend products which most readily suit given applications . . . even packaged control sets that are so perfected that most press hazards are eliminated. Both hands must be used at once and can't get into mischief. Any machine using mechanical clutch, shears, brakes and friction clutches can use special controls. You may be very surprised at how painlessly Schrader can turn your idea into fact. Information is available by writing directly to us . . . and our distributors are conveniently located for fast delivery. Address A. Schrader's Son, Division of Scovill Mfg. Co., Inc., 477 Vanderbilt Avenue, Brooklyn 38, N. Y.

Schrader
a division of SCOVILL

QUALITY AIR CONTROL PRODUCTS

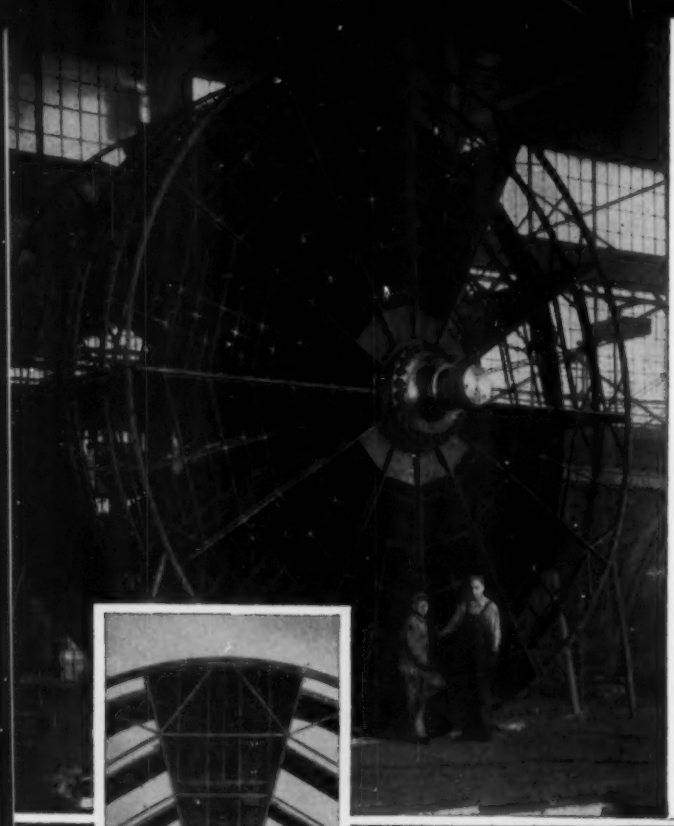
A. SCHRADER'S SON • *Division of Scovill Mfg. Co., Inc.*
477 Vanderbilt Avenue, Brooklyn 38, N. Y.

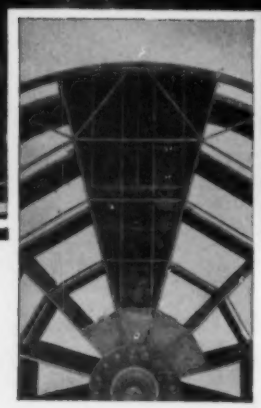
Please send latest informative booklets which show Schrader's complete line of Air Control Products.

Name_____ Title_____

Company_____

Address_____



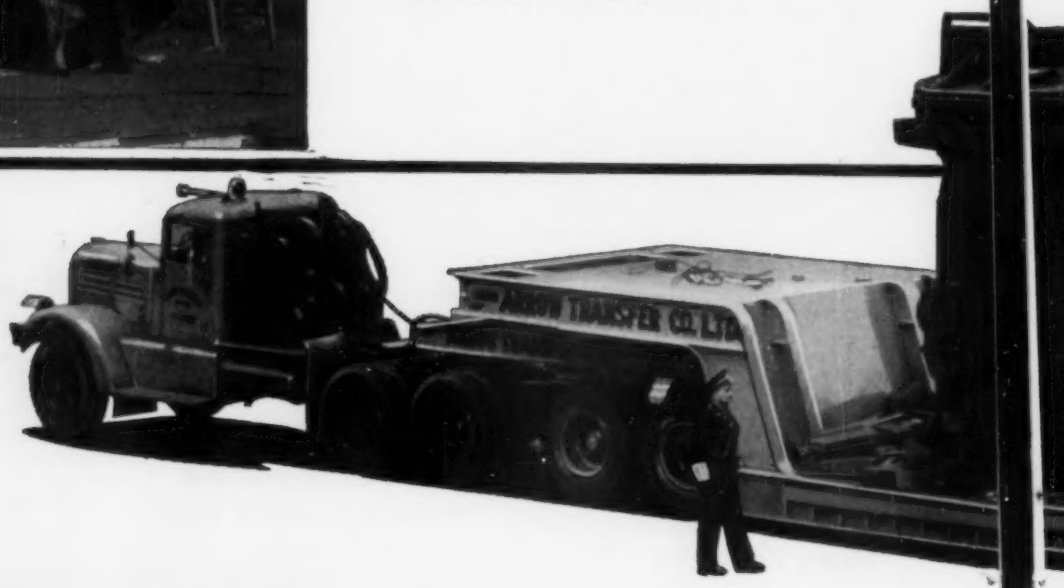


INCREASES CORROSION RESISTANCE. The huge rotor illustrated here is the main structural component of a Ljungstrom Horizontal Air Preheater. Three of these units, designed to serve a 1,900,000 pounds-per-hour-capacity boiler, are among the largest ever manufactured by The Air Preheater Corporation, New York. Each complete preheater weighs 270 tons. The rotor itself—25′2″ in diameter and 10′10½″ deep—when fully loaded with the heating element, weighs about 390,000 lbs.

Because sulfur in the gases combines with moisture—sulfuric acid is formed when the temperature drops below the dew point at the "cold" end of the rotor—corrosive action can be highly severe in this area. Corrosion means maintenance.

Aiming at a reduction in maintenance, the manufacturer cooperated with the U. S. Bureau of Mines in exhaustive tests to determine the corrosion resistance of various materials under sulfuric acid attack in air preheaters. These tests, made over a 5½-year period, showed that the corrosion rate of low-alloy USS COR-TEN Steel was *lower* than all but one of the *high* alloy steels tested, was less than one-half that of carbon steel and less than one-fourth that of cast iron.

As a consequence, USS COR-TEN Steel is specified for the cold end heating elements and containing baskets on all conventional boiler applications. Where unusually severe corrosion is anticipated, USS COR-TEN Steel is also specified in all or part of the rotor including diaphragm plates, bar stock, rim angle and filler plates.



INCREASES DURABILITY, REDUCES COST. Tote boxes have to take quite a beating. Used for handling, storing and shipping automotive and other parts, they must be able to withstand plenty of rough treatment.

That's why the "Hamlintainer" shown here—a *collapsible* tote box that sets up and folds flat in less than 20 seconds—is now built entirely of USS COR-TEN Steel. COR-TEN Steel's greater strength, 50% higher than carbon steel, makes it possible to build the "Hamlintainer" up to 100 lbs. lighter than carbon steel units, yet so strong and rigid that it will withstand long and rugged service and is not susceptible to bending and distortion. The fact that the COR-TEN Steel ends and sides have the stamina needed to permanently maintain their shape is of utmost importance. It means that throughout its long life the box will always be easy to set up, fold and stack flat.

As compared to the metal construction used in an earlier design, USS COR-TEN Steel makes the "Hamlintainer" not only stronger, more rigid and more durable but also less costly to produce, according to the manufacturer, Hamlin Metal Products Co., Akron, Ohio.

UNITED STATES STEEL
USS
HIGH STRENGTH STEELS
1933 1957
24 YEARS OF PERFORMANCE

High-strength USS COR-TEN Steel pays off in equipment like this

What does your product need to make it better? Greater durability? Bigger capacity? Cheaper maintenance? Lower operating cost?

Do you want to make it stronger, lighter in weight, more corrosion resistant, better able to withstand abrasion, impact and fatigue?

You can obtain any or all of these important money-saving benefits—at little or no increase in cost—by the proper use of high-strength low-alloy USS COR-TEN Steel.

USS COR-TEN Steel is distinguished by its superior resistance to atmospheric corrosion—4 to 6 times that of carbon steel, 2 to 3 times that of copper steel.

In thickness of ½" and under, COR-TEN Steel has a minimum yield point of 50,000 psi and a minimum tensile strength of 70,000 psi. In resistance to abrasion, shock and impact, it is superior to structural carbon steel. Its fatigue resistance is 60% greater.

Thus, when used to directly replace carbon steel, USS COR-TEN Steel will materially increase the strength and durability of vital parts *without* increasing their weight. Or it can be used in thinner sections (1) to reduce weight without sacrificing strength or (2) to increase the capacity of equipment without increasing gross weight or the power required to move it.

You will find our 174-page "Design Manual for High Strength Steels" extremely useful in applying USS COR-TEN or our other High Strength Steels, USS MAN-TEN and USS TRI-TEN "E" to your product. For free copy, simply write on your company letterhead to United States Steel, Room 2801, 525 William Penn Place, Pittsburgh 30, Pa.

INCREASES STRENGTH, SAVES WEIGHT. Shown here hauling a 117-ton transformer, this 150-ton-capacity trailer—built by Columbia Trailer Company, Vancouver, B. C., for the Arrow Transfer Company of that city—is the largest trailer ever built in Canada.

This 80-ft.-long trailer is constructed almost entirely of USS COR-TEN Steel. It is about 25% lighter than if it had been built of structural carbon steel. Specifically designed for handling transformers of giant size, it has a depressed center deck which makes loading and unloading easier and keeps center of gravity low to prevent danger of upset.

Says the manufacturer: "We have found that when a trailer is made from structural carbon steel there is a greater possibility that it can be permanently damaged from overloading than in the case of a similar unit made from high strength steels. That's why, in designing trailers of this type, we always use USS COR-TEN Steel. This construction gives us the high strength needed, plus excellent corrosion resistance and freedom from excess weight—all very important in equipment like this."

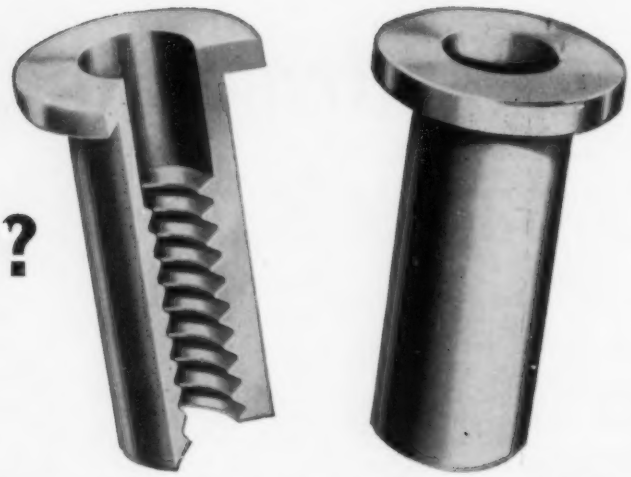
UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND • COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
NATIONAL TUBE DIVISION, PITTSBURGH • TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. • UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS HIGH STRENGTH STEELS

USS MAN-TEN • USS COR-TEN • USS TRI-TEN

UNITED STATES STEEL

What are they?



B. F. Goodrich Rivnuts®–the only one-piece blind fasteners with threads

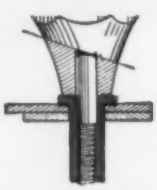
If you have a fastening problem, solve it the easy way—with B. F. Goodrich Rivnuts. One man can install Rivnuts blind from one side of the work. It takes only a few seconds—speeds assembly and cuts costs as much as 50-90% depending upon the applications.

Rivnuts are stronger, too, because they provide at least 6 clean threads, even in thin sheet metal. By eliminating welding, tapping and cleaning, Rivnuts eliminate costly steps in production and straighten out assembly lines.

Rivnuts come in a variety of types and sizes and materials to solve your specific fastening problem, in sheet metal, wood, plastic. For complete information, send for the FREE RIVNUT DEMONSTRATOR. It shows with motion how Rivnuts fasten *to* and *with*. B.F.Goodrich Rivnuts, Dept. PE-87, Akron, Ohio.

Rivnuts® provide at least 6 clean threads in one simple operation

1 Rivnut is threaded onto pull-up stud of a manual or pneumatic heading tool.



2 Rivnut is inserted—head firmly against work—tool at right angles to work.

3 Tool lever operates pull-up stud, forming a bulge in the Rivnut shank.

4 After upset, Rivnut threads are still clean and intact ready for screw attachment.

B.F.Goodrich

B.F.Goodrich Aviation Products

a division of The B. F. Goodrich Company, Akron, Ohio

TDA® BRAKES

if it rotates...we can control it!

New lightweight . . .

Fabricated steel brake shoes weigh many pounds less than cast shoes. Binding or freezing up is eliminated because double web construction permits limited area fit with one piece cam rollers. Wear areas of the webs are heat treated for long life.

Unit-mounted . . .

All brake parts are mounted on the spider for compactness. Efficiency is higher and correct cam shaft alignment is assured with close coupled cam shaft and chamber bracket.*

"P" SERIES POWER BRAKES

designed for heavy-duty automotive service

Here is a brake that gives longer, trouble-free service for trucks, trailers, and all types of industrial and road equipment. These heavy-duty "P" Series Brakes are easy to maintain in service. Simplicity of design is the keynote—with brake, air chamber, and cam shaft all mounted as a unit.

The outstanding features of the Timken-Detroit® "P" Series Brakes give increased economy and performance. Operating temperatures are lower and lining life longer because open-type spiders assure good internal ventilation and rapid cooling. Timken® "Econo-liners" are tapered to provide greatest thickness where greatest lining wear normally occurs.

A constant-lift "S" type cam assures uniform application of brake shoes for maximum control and immediate response. Brake adjustments are quick with easily accessible slack-adjusters. Long wearing nylon bushings assure smooth operation with minimum maintenance.

"P" Series Power Brakes are available in a complete range of capacities and sizes to fit every operating requirement.

*"P" Series Brakes are also available with inboard chamber mounting for special applications.

©1956, R S & A Company

TIMKEN Detroit BRAKES
ROCKWELL SPRING AND AXLE COMPANY
The Accepted Standard

For every industrial, agricultural or automotive application where braking is required!

TDA plants at: Detroit, Michigan • Oshkosh, Wisconsin • Utica, New York Ashtabula, Kenton and Newark, Ohio • New Castle, Pennsylvania

Timken-Detroit Brake Division
Rockwell Spring & Axle Company
Dept. PE-87, Ashtabula, Ohio

Please send me further information on your "P" Series Brake.

Name _____ POSITION

Company _____

Address _____

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UNICHROME
Trade Mark

News about
COATINGS for METALS
Metallic.....Organic.....Decorative.....Protective

New type chromium plate improves products

Why Crack-Free Chromium gives superior finish

Regular chromium plate develops a network of cracks as it is deposited. Through these defects, corrosives reach the underlying metal. Deposits from the Unichrome Crack-Free Chromium Plating Process remain structurally sound and continuous. This explains the wide difference in degree of corrosion protection obtained.

OTHER PROPERTIES

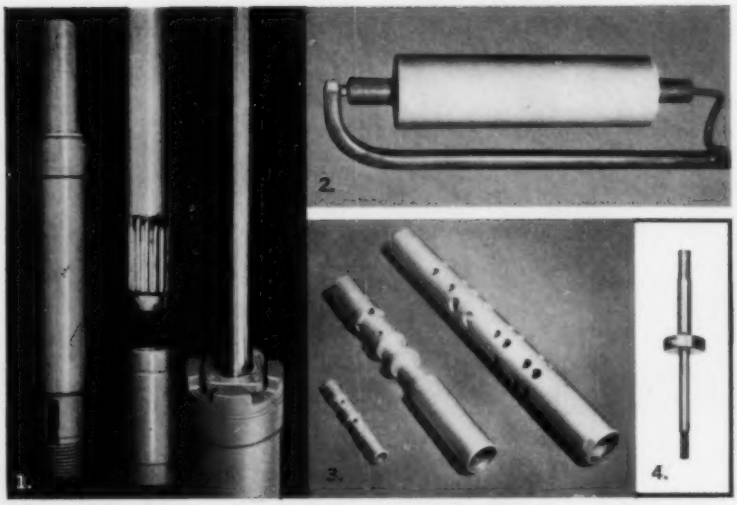
Crack-Free Chromium also provides:

1. Increased ductility, so that expansion and contraction cause no cracks.
2. Improved non-galling, non-seizing properties.
3. Low friction, resistance to wear.
4. Hardness (500 to 700 Knoop).
5. Excellent leveling action to help cover surface irregularities and reduce grinding needs.
6. Protection to the base metal without undercoats.
7. A satin matte *decorative* finish that can be applied directly to zinc die casting as well as steel. It buffs readily to high luster.

Bulletin CFC-2 gives more details on self-regulation and other features.

Unichrome is a trademark of Metal & Thermit Corp.

METAL & THERMIT
CORPORATION
General Offices: Rahway, New Jersey
Pittsburgh • Atlanta • Detroit
East Chicago • Los Angeles
In Canada: Metal & Thermit—United Chromium of Canada, Limited, Rexdale, Ont.



A few of the applications where Unichrome Crack-Free Chromium can be used to protect against corrosion, heat, wear. (1) Washer shafts and sleeve; hydraulic ram. (2) Roller. (3) Hydraulic control valve plungers. (4) Component part of power producing mechanisms.

Difficult problems created by heat, wear, corrosion solved by Crack-Free Chromium

Field reports confirm that Unichrome Crack-Free Chromium is truly a new type of chromium plate with valuable characteristics. It is being used in applications once thought impractical for chromium or other deposits.

IMPROVING HYDRAULIC SYSTEMS

On hydraulic rams, power steering shafts, hydraulic jacks being plated with Crack-Free Chromium, relatively thin deposits protect against corrosion, reduce friction and wear. Where aqueous hydraulic fluid penetrated the cracks in .003 to .005" of ordinary chromium, a .0009" Crack-Free deposit stopped it.

Washing machine and typewriter parts, spline shafts, piston rings, relay armatures are other applications where corrosion problems have been solved.

COMBATING THERMAL SHOCK

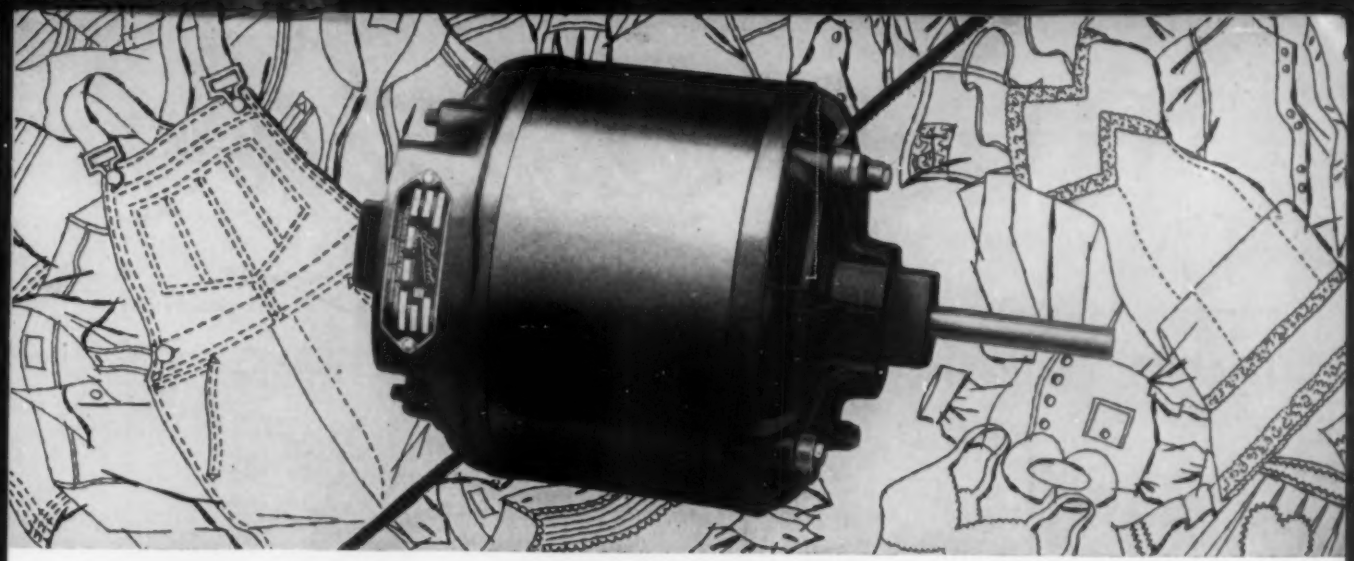
Spouts for pouring 2250°F. molten glass into molds last four times longer when plated with Crack-Free Chromium instead of ordinary chromium. Molds for TV tubes, subject to corrosion at the cracks in ordinary chromium, now last 5 to 10 times longer.

Increased ductility combines with resistance to thermal shock for other benefits. Faster, deeper grinding cuts can be made on this new chromium without fracture. On renewed transmission cams, this plate didn't fracture in service, whereas ordinary chromium did on 30% to 40% of the cams.

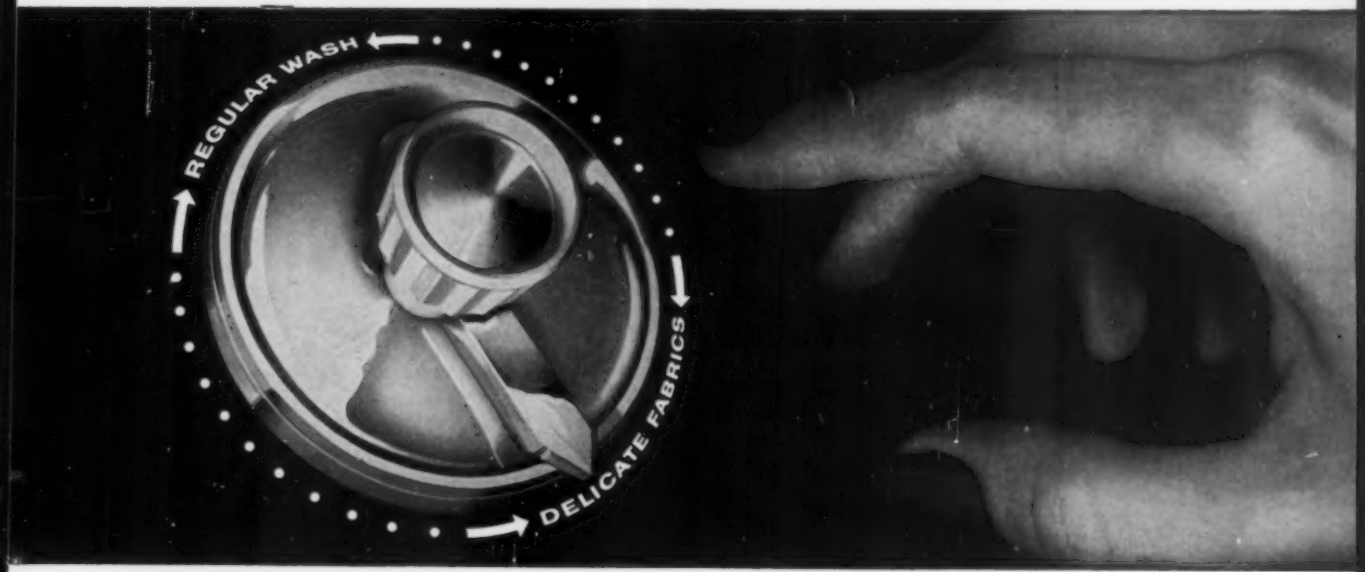
SLOWING DOWN WEAR

Crack-Free Chromium enables one user to increase life of textile machine rolls by 400% while cutting chromium deposit thickness 95%. It has also increased service life of drills, taps and reamers by 300%, compared with ordinary chromium.

Send for Bulletin CFC-2.



PACKARD ELECTRIC / *NEW... custom-tailored washing machine motor*



FHP MOTORS / *Provides power for two washing speeds... electrically!*

It's an old idea based on need. Make the agitator speed variable. Then, both light and heavy clothes could be thoroughly washed without harming fabrics.

There were no two-speed appliance motors available with enough power at both speeds. Mechanical means, such as gears, belts and pulleys, clutches, etc., cost too much, took up too much space, made too much noise and caused too many maintenance problems.

A Packard Electric motor engineering team was first to solve the problem with a compact, two-speed unit that had just the amount of speed, power and torque required. And washing machine manufacturers who worked out the solution with Packard Electric engineers have had a big competitive advantage ever since.

What's more, there are further savings in assembly when you buy Packard. That's because Packard will deliver a motor complete with special mountings and accessories to simplify your assembly procedures.

Packard Electric research and engineering teams have a long record of accomplishment in the custom-built motor field. And, even now, new ideas are on the boards to help our customers produce better, lower priced products for the appliances of tomorrow.

Packard Electric

Warren, Ohio

GM GENERAL MOTORS

Division of General Motors

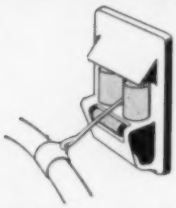
TAYLOR Laminated Plastics Vulcanized Fibre *Shop Talk*

TAYLOR FIBRE CO.

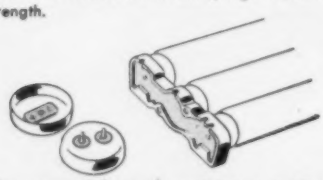
Plants in Norristown, Pa. and La Verne, Calif.

PHENOLIC—MELAMINE—SILICONE—EPOXY LAMINATES • COMBINATION LAMINATES • COPPER-CLAD LAMINATES • VULCANIZED FIBRE

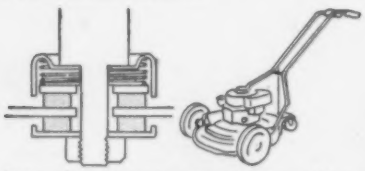
Tips for designers



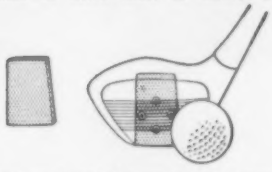
Hose reel rollers, made of Taylor Grade C thick-walled phenolic tubing, are part of cable attachment for gas pumps . . . selected for good wear and corrosion resistance, high mechanical strength.



Fluorescent tube ends are fabricated of Taylor Grade X phenolic laminate . . . for mechanical strength, electrical insulation qualities, good punching and machining qualities.



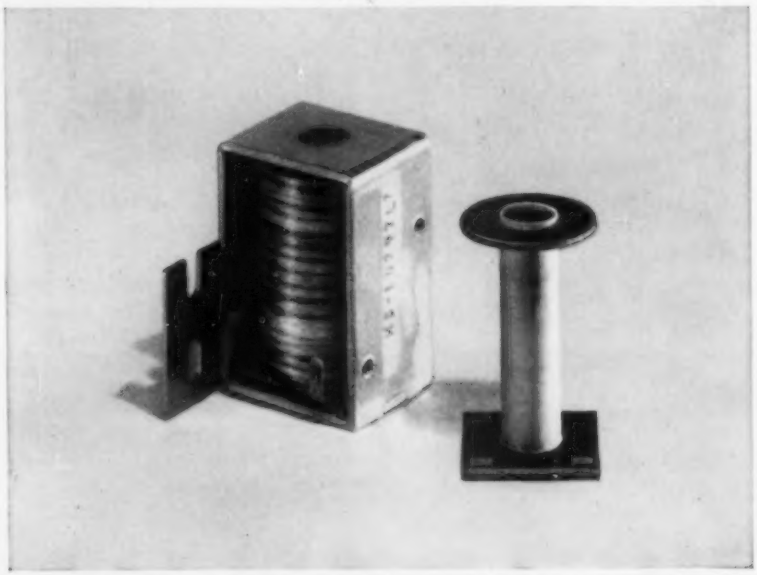
Rotary lawn mower utilizes abrasion resistance of Taylor phenolic laminate washer in slip-clutch attachment of drive shaft to cutting blade.



Insert in face of golf club, made of Taylor vulcanized fibre . . . withstands severe impact . . . gives long-lasting, long-hitting surface.

TAYLOR SUPERIOR COPPER-CLAD LAMINATES

Taylor GEC (glass epoxy) Copper-Clad and Taylor XXXP 242 cold punching (paper-phenolic) Copper-Clad. Taylor uses high purity rolled copper on base materials with outstanding electrical properties.



Both end pieces and the tube of this coil form assembly for radio frequency transformers are fabricated by Taylor for the Guardian Electric Mfg. Co. Taylor Grade G-5 sheet and tubing are used . . . for high mechanical strength, for high arc, flame and heat resistance, as well as superior tensile, flexural and impact strengths.

Accurate laminated plastic components can shorten your production steps . . .

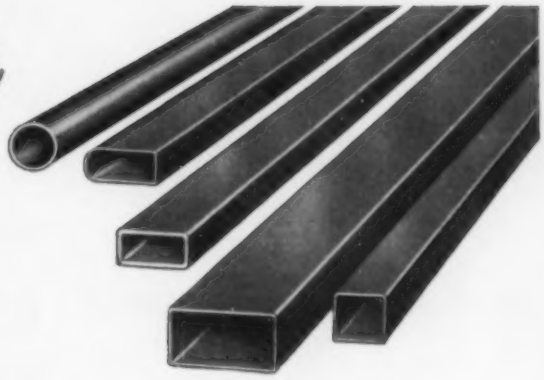
If close-tolerance work—such as this coil form assembly for radio frequency transformers—is one of your problems, then check with Taylor. This complete part was fabricated to very close tolerances by Taylor's Fabrication Division. The material—Taylor Grade G-5 laminate sheet and tubing—was selected for its high mechanical strength and for superior arc, flame and heat resistance.

Precision fabrication of laminates and vulcanized fibre is difficult . . . but Taylor can and is doing it, in a great variety of Taylor grades, and to extremely close tolerances. Many manufacturers have solved their fabrication and assembly problems with the help of this Taylor facility, by having parts supplied completely fabricated to specified tolerances, ready for final assembly. With specialized equipment and advanced techniques, Taylor is prepared to simplify your production problems, safeguard delivery schedules, and eliminate inventory headaches.

You can put Taylor's Fabrication Division to work right now, helping to improve your product. Design to closer tolerances—Taylor can do the job. Taylor is equipped to handle any kind of fabrication—punching, drilling, grinding, forming, milling, and turning. You improve your product . . . reduce material costs.

Taylor's fabricating facilities and engineering staff are at your service. Contact your nearest Taylor sales engineer for a discussion of your particular requirements.

Another Plus . . . from Brainard



Tubing:

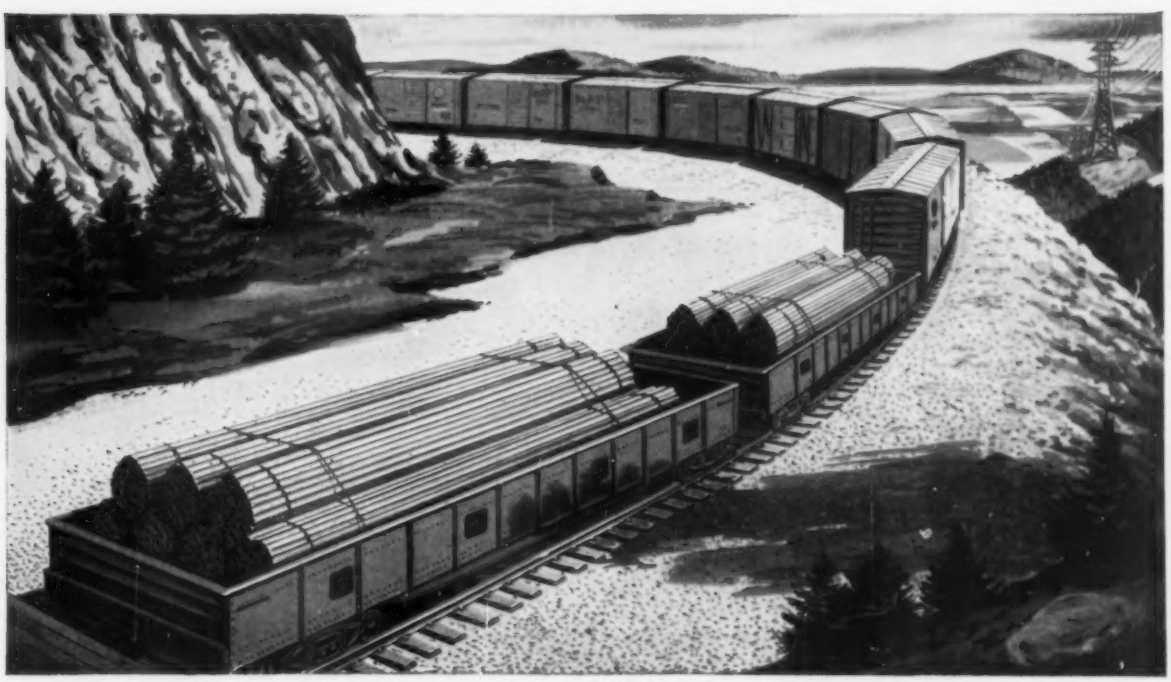
Assured delivery from an integrated mill...

As a buyer of steel tubing, what does the phrase . . . "from an integrated mill" mean to you?

To most of our customers it means just this: no company likes to have its markets jeopardized by production slow downs resulting from material shortages. When the "material" happens to be tubing and the supplier is an integrated mill such as Brainard, such shortages are virtually nonexistent.

As an integrated mill, Brainard is not dependent on outside material sources. The corporation of which Brainard is a part controls tubing production from raw material source to finished product: thus customers are assured of an uninterrupted supply.

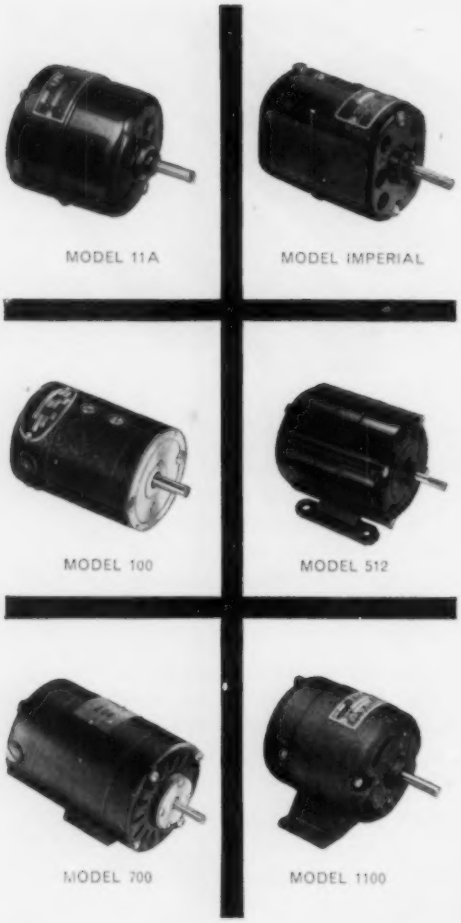
So, whether you buy tubing in small quantities or carload lots, you can benefit from this year-in-year-out dependability of supply by placing your orders with Brainard.



Brainard Steel Tubing

SHARONSTEEL

Brainard Steel Division, Sharon Steel Corporation
Griswold Street, Warren, Ohio



MORE THAN *50,000 DIFFERENT SPECS* HAVE BEEN FILLED BY THESE 6 HOWARD UNIVERSAL AND D.C. FRACTIONAL H.P. MOTORS

These 6 Howard motors account for over 50,000 specifications, both military and commercial. One reason for this wide use is Howard's ability to produce variations *exactly* suited to specific needs.

Howard motors have such field-proven engineering features as automatic slot cell insertion, which practically eliminates "grounds;" Zanderoll processed double dipped and double baked armatures providing deep, uniform varnish penetration for high bond strength and rock-hard coils minimizing "shorts and opens;" improved brushholder construction for accurate alignment and longer life; 2-stage, 3-plane dynamic balancing; and automatic winding for tough compact coils, giving uniform performance.

If you are currently using universal and D.C. motors from 1/200th to ½ H.P., check with Howard today.

GEAR REDUCTION UNITS		
Model	Ratio	
	min.	max.
11A	3:1	2700:1
Imperial	3:1	2700:1
100	3:1	2700:1
512	3:1	2700:1
700	21.5:1	2600:1
1100	3:1	2700:1

ELECTRICAL SPECIFICATIONS

	MODEL 11A		MODEL IMPERIAL		MODEL 100		MODEL 100		MODEL 512		MODEL 700	
	SERIES MOTOR	SHUNT MOTOR	SERIES MOTOR	SHUNT MOTOR	SERIES MOTOR	SHUNT MOTOR	SERIES MOTOR	SHUNT MOTOR	SERIES MOTOR	SHUNT MOTOR	SERIES MOTOR	SHUNT MOTOR
NO LOAD SPEED (RPM)	15M	3.5-10M	18M	3-10M			@ 15M	3.5-10M	15M	2-9M	18M	9M
FULL LOAD SPEED (RPM)	5-10M	3-8M	5-10M	1.5-8M	5-10M	1.8-6M	5-10M	3-8M	5-10M	1.8-6M	5-10M	1.8-6M
MAX. H.P. CONT. @ MAX. R.P.M.	1/75 No Fan	1/75 No Fan	1/15	1/20	1/50	1/50	1/50	1/50	1/10	1/12	1/4	1/8
MAX. H.P. INTER. @ MAX. R.P.M.	1/20	1/20	1/8	1/10	1/13	1/13	1/15	1/15	1/5	1/6	1/2	1/4
FULL LOAD AMPS. CONT. @ 115V.	.4	.4	1.1	1.1	.35	1.6 at 24V	.60	.45	1.5	1.5	3.2	1.7
FULL LOAD AMPS. INTER. @ 115V.	.75	.75	2.0	2.0	1.0	5 at 24V	.70	.50	3.0	3.0	5.6	3.3
% EFF. AT FULL LOAD CONT.	30	30	35	30	35	35	40	35	50	45	60	50
% EFF. AT FULL LOAD INTER.	35	35	50	45	45	45	45	45	60	55	65	55
VOLTAGES	12-115	6-120	24-115	6-120	12-120	6-32	12-230	6-120	24-230	12-230	24-115	6-230
ROTATION	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.

Maximum H.P. ratings are shown. Variations are available for less power to meet application requirements.

HOWARD

Other Howard motors: UNIVERSAL & D.C. 1/200 to 1/2 h.p. • SHADED POLE 1/2000 to 1/8 h.p. INDUCTION 1/1400 to 1/8 h.p. • SERVO MOTORS • GEAR MOTORS • BLOWERS

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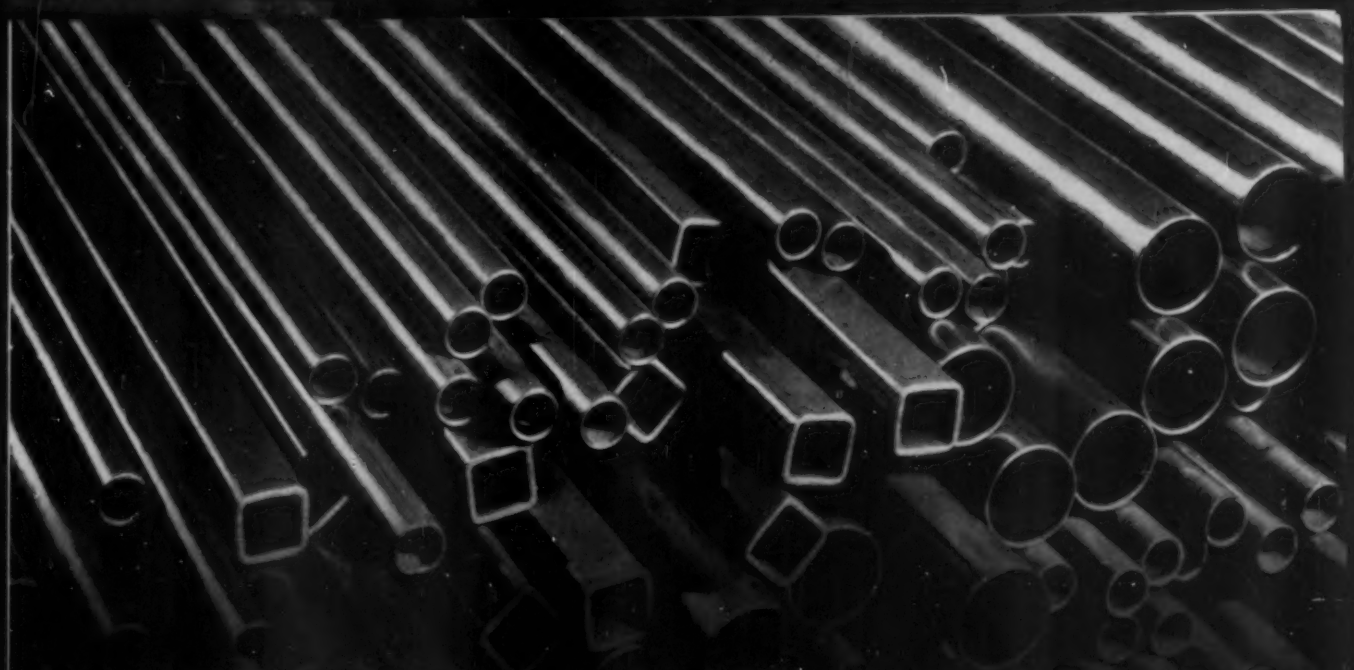

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WHY WAIT FOR DELIVERY when you can get all the top-quality Seamless Steel Tubing you need from your close-at-hand USS Shelby Seamless distributor?

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WALLS WITHOUT WELDS

UNITED STATES STEEL

R B&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By John S. Davey

Nuts — their use and abuse

With bolts tightened to high load levels, nut performance becomes critical.

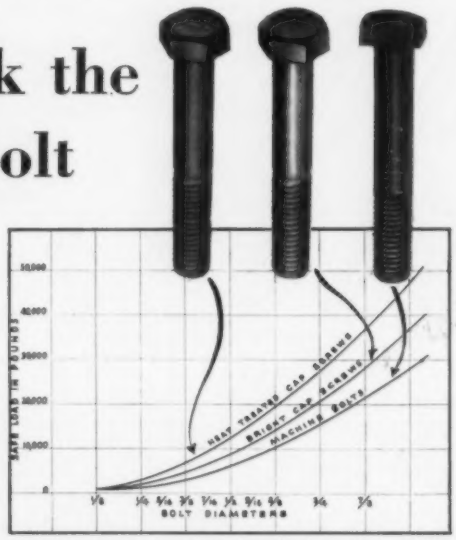
A nut produces bolt tension by rotating and advancing on the bolt threads. To do this, there must be a mating condition of threads, which is influenced by thread lead. Lead is a matter of tolerance only before bolt is stressed. When tightened, the nut is then under compression and threads tend to contract; the bolt is in tension, and threads tend to stretch. Lead of thread is affected–elastically *before* yield point, permanently *beyond* it.

This shortening of one lead and lengthening of the other has two effects. (1) The load distributes unequally along the threads (2) Torsion on bolt increases. Something has to give. For high tensile bolts especially, it is better for the nut to do so. A nut therefore should be soft enough so that it deforms plastically and compensates for off-lead. If it does, it *distributes* the load and can advance to increase tension.

"SOFT" NUTS DO MOST JOBS

"Soft" nuts do adjust more readily than hard ones under these severe conditions. While such nuts may not be as strong in shear as heat treated ones, the important point is the bolt tension they produce. As long as the nut can pull the bolt well into its plastic range, it is doing more than its share of the job.

How to pick the right size bolt



When it comes to uniformity of dimension, quality of head and thread, and ease of assembly, all RB&W cold headed fasteners are the same. They differ mainly in tensile strength as shown here.

ALMOST all bolt and cap screw strength requirements can be satisfied from three types of *standard* fasteners without recourse to costly special alloys. In the widely used middle range of sizes, the problem is one of deciding which makes the best joint, or which proves the most economical for the job.

MORE FOR LESS

Suppose, for example, you need a bolt safe for 20,000 pounds of loading. As the chart shows, you could use an RB&W 7/8" square-head bolt, a 3/4" bright cap screw, or a 5/8" heat treated one.

If you have a lot of holes to fill, use the larger, lower strength fasteners. But to cut down number of bolts, or their size (and therefore cost), go to the higher tensiles. However you gain nothing if you don't tighten high tensile bolts to their full strength.

HOW COSTS COMPARE

In terms of holding power: For each $1.00 in high tensile bolts, it costs $1.50 to provide equivalent clamping force with bright cap screws; or $1.65 with machine bolts.

For more suggestions on fastener economy or for copy of above curves, write Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, N.Y.

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

Spin-Lock Nuts dig in to stay tight

The photograph shows the many hardened "anchors" on the flange of a Spin-Lock Nut. These "ratchet-action" teeth require 20% more torque to loosen than to tighten. They bite in as the nut turns down on its seat. Like Spin-Lock Screws, these nuts can stay put in products subject to vibration and cyclic temperature variations. Send for bulletin.

PERSPECTIVES

in design and development . . .

The Trouble With MIL Specs

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Mr. Frank A. Thompson of the Navy's Bureau of Aeronautics, Missile Division, says, "One of the main faults is the policy of designing a specification around one particular, known, piece of equipment, then making a general spec out of it. This is done before the spec is circulated to get industry's viewpoint on what should be a general spec for that piece of equipment. This is true also of environmental problems. The military does not contact industry to find out what experience it had with similar systems. The environment figures are more or less pulled out of a hat. The best information they had at the time they wrote into the specifications; then plugged in the well known aircraft industry's safety factors, and the results were considered adequate. We have learned now that this is not the way to do it."

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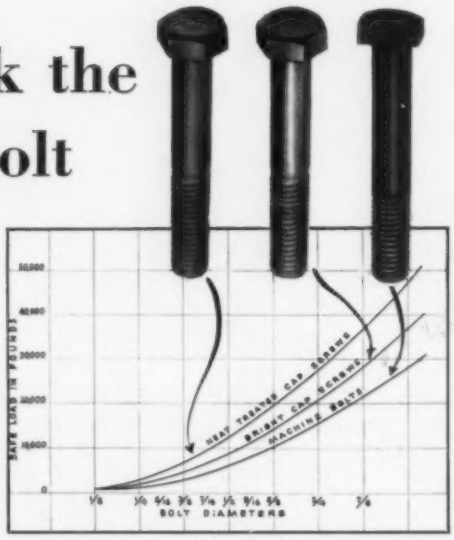

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(Continued on page 131)

New nylon gun body is made in one piece, integrating three former parts in one. It weighs only 5 ounces—is easy to handle, easy to clean. Flashing, buffing and plating are eliminated because the smooth, black finish is *in* the nylon.

Chicago Molded helps develop nylon body for new

Sears-Roebuck paint spray gun...

- that's 66% lighter • practically indestructible
- tighter sealing than die cast aluminum
- eliminates several machining, polishing and plating operations

This new spray gun will help the do-it-yourselfer to do a more professional job. The entire unit—made by the Electric Sprayit Division of Thomas Industries Inc.—offers home hobbyists new ease of cleaning, ease of handling and greater durability. Models of this new spray gun will be offered by Sears-Roebuck under the Craftsman label, and by independent stores under the Sprayit name.

The behind-the-scenes story is the new application of nylon (Du Pont's Zytel) developed after nearly two years of cooperative research by engineers of Chicago Molded, Electric Sprayit and Sears. By injection molding the entire gun mechanism in a single cavity, several machining, polishing, buffing and plating operations normally required for metal guns have been eliminated. At the same time, the finished product is two-thirds lighter—an important fatigue factor in spraying. And the nylon-to-metal screw threadings make tight seals, guard against leakage of compressed air. Furthermore, nylon is not affected by common solvents, greases, alkalis or oils, and dried paint does not tend to stick to its smooth, lustrous surface.

Whatever your new product needs, you'll find it pays to call in Chicago Molded. CMPC engineers keep abreast of developments in all plastics to help you make your product more saleable, yet less costly. *That's why 66% of our business comes from firms we've served for over 20 years.*

Write today for a free subscription to Plastics Progress, Chicago Molded's data-packed magazine on up-to-date developments in plastics.

Chicago Molded Products Corporation

1032 North Kolmar Avenue, Chicago 51, Illinois

and will be reflected in future editions. At the moment the services are having growing pains with this new approach.

For example: relays are built to numerical requirements in MIL specs, yet a company with certain requirements for a relay could not find one that would stand up under the conditions to which the relay is being subjected. However, the relay had passed tests which required the meeting of the numerical specs. This is a good example of not knowing the environment in which the part will operate.

Unnecessary Testing

The tests that component manufacturers give to a part in many cases are more than those required by the specifications, and they would so state. Often the tests given to a part are improper. For example: a sinusoidal type of vibration test would be made when actually a noise type of vibration is encountered in operation with a random amplitude that has large peaks, perhaps larger than the highest in the sinusoidal test. Some parts are vibration tested in combinations of the three planes. No spec requires this. What should be done more often is a simultaneous test of vibration, temperature, and altitude.

Unnecessary Accuracy

It apparently is becoming standard practice today to develop, say, a voltage regulator with the closest possible voltage regulation and frequency control, even if a spec does not require such accuracy. The feeling is that the more precise the control, the greater are the manufacturer's chances for getting the contract. The penalties that a piece of equipment pays for being overly accurate are large, and they all add up to increased unreliability, not to mention increased cost. Such false criteria arise and end up being emphasized in the specifications.

The operating time of a component is often specified to be much longer than is really necessary. Some missile components, for example, which actually perform for only a few minutes are often made to operate for a few hundred to 1000 hours. This is somewhat of a bone of contention. The procurement people are of the opinion that long life is correlated to reliability, therefore "let's specify the long lived devices."

Greater Stress on Testing

"Some contractors let success go to their heads," says Frank Thompson. "One felt that with many successful missile flights with his particular product unchanged, it would be a waste to make further vibration tests at a higher frequency. I feel that this is unrealistic for there have been many failures which the contractor calls 'random failures,' and about which he knows nothing. We think that high frequency vibrations cause it and want him to test for it. He objects, saying testing is expensive."

Higher reliability standards, which includes the problem of variability of characteristics of component parts and the random failure of rate today puts a far greater stress on testing than was formerly the case. This requires more expensive test equipment, making it difficult for the small companies not having this equipment to get into some defense programs, because such equipment cannot be charged as part of contract costs.

Thompson said, "One small company got into military work for the first time in a project where it was required to meet environmental specifications. The executives of this company figured they knew what this would entail, and because of their low bid they were given the contract. When they got into the environmental testing alone they lost thousands, because they could not meet the specs with the test equipment they had and were forced to rent the equipment from other companies in the area. It turned out that to fulfill their obligation to the government they lost money equal to the total value of the contract. This points up the need for a standard testing specification." —PAUL ANDERSON

6 SPEED NUTS® replace 10 fasteners ...and costs drop 80%!

Six Tinnerman SPEED NUTS replaced 10 weld nuts on the Gibson Window Air Conditioner... and production costs dropped more than 20 cents per unit!

Working with the designers at Gibson Refrigerator Company, Division of Hupp Corporation, Tinnerman engineers suggested using four "J" Type SPEED NUTS to fasten the front panel to the air conditioner cabinet. These one-piece, self-locking, spring-steel fasteners snap in place by hand; are self-retained in screw-receiving position. They also used two Flat Type SPEED NUTS to fasten the window mounting channel to the cabinet.

By eliminating ten weld nuts, Gibson was able to divert a spot welding machine to other uses, reduce materials handling, simplify and speed up assembly. They cut costs right down the line — without sacrifice of product quality!

Savings like this are being made every day when manufacturers switch from ordinary fasteners to Tinnerman SPEED NUT Brand Fasteners. Over 9000 variations are available to handle practically any fastening job, from tiny transistors to huge freight cars.

Send for complete data on how you can make important assembly-cost savings. And investigate the possibilities of having a Tinnerman Fastening Analysis made of your products. Call your Tinnerman representative, or write to:

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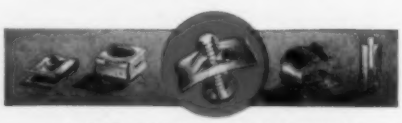

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Product Engineering

WANTED: MEN WHO TALK BACK

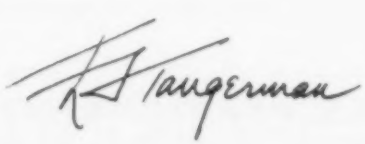
"If two of us in the same office agree on everything, one is unnecessary." Thus, some years ago, one engineer explained the importance of several points of view. His opinion was in sharp contrast to the legendary Hollywood belief that each executive must be trailed by his own corps of "yes men", agreeing with every statement, applauding every decision.

Engineering thrives on intelligent disagreement. A complex modern design cannot be the product of a single mind, no matter how competent that mind may be. The core idea must be expanded with proper materials and mechanisms, with production know-how, with clean and eye-catching styling, and ultimately with sales-wise marketing. In our era of highly competitive mass production and sales, fractions of a cent may determine whether a product fails in the marketplace, details may prejudice the buyer of a major machine.

Thus everyone concerned with product planning must ask—and answer—during development the questions that the customer will otherwise ask later. He must be concerned with both the big questions and the little ones, because little doubts have a way of looming large in the buyer's mind.

There are, in business as well as in Hollywood, those self-styled geniuses who can brook no questioning of their inspirations, those master men who can make no mistakes. They seek no outside opinions, can stand no criticism. The minds around them must inevitably leave—or atrophy from disuse. No man can build—or maintain—an intellect by constantly saying yes.

The doctor can bury his mistakes, the lawyer can appeal, but the engineer must live, or die, with them. And whether the engineer actually made the error, or merely kept silent while someone else did, he'll be blamed for it. That makes it advisable for him to talk back, if necessary, at the beginning. There can be no yes men in engineering.



FACTS

about

NEW DEPARTURE BALL BEARINGS

MAST-GUIDE BALL BEARING SIMPLIFIES DESIGN and LOWERS MAINTENANCE COST!

New Departure's mast-guide ball bearings bring lift truck designers greater variation in upright construction. These bearings eliminate sliding metal-to-metal contact and multiple bearings of complex design . . . as well as need for maintenance by the end user.

The mast-guide bearing is integrally sealed and lubricated for life. The heavy-section outer ring gives the added beam strength and shock resistance required for rugged duty. The extra width of the outer ring provides more contact surface to reduce mast brinelling. The hardened and ground "tire" is part of the bearing itself, resulting in lower cost for the lift truck manufacturer.

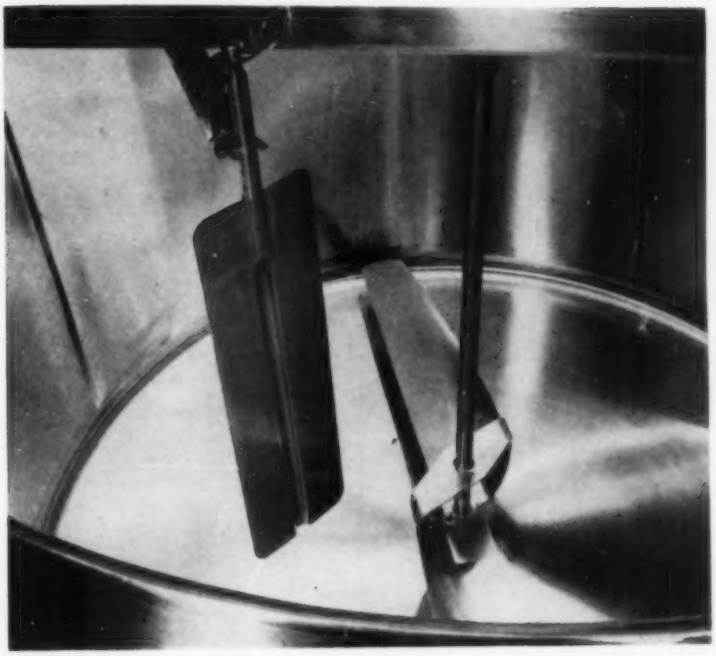
These bearings give the same advantages common to all New Departure ball bearings—unexcelled long-life performance in handling heavy combined loads . . . lowest operating friction for consequent improvement in horsepower efficiency. Also, there is no need for relubrication or adjustment throughout years of service.

Write for examples in *your* field where New Departure ball bearings and bearing engineering service help make good products better.

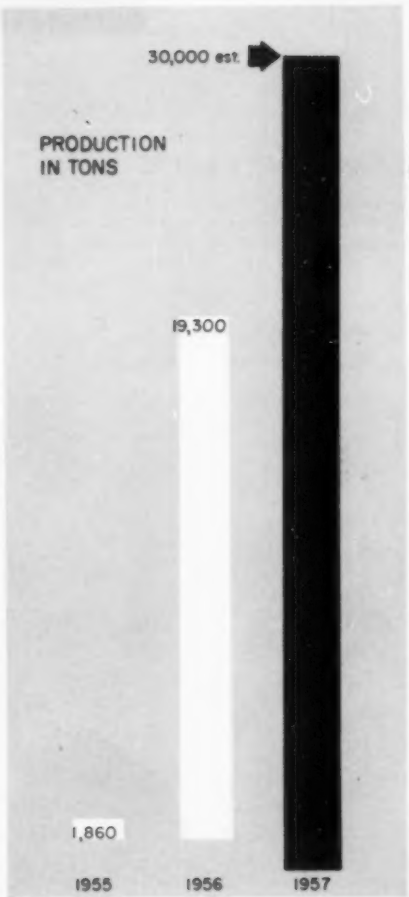
Photo: Courtesy of Clark Equipment Co.

BALL BEARINGS MAKE GOOD PRODUCTS BETTER

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.



Better strength and weldability . . .
make "200" series stainless steels an attractive alternative to straight 18-8 steels in many new assembled metal products. Typical is this experimental dairy processing tank built by Cherry-Burrel Corp.



From a modest 2000 tons in 1955, production of chrome-manganese stainless steels may break 30,000 tons this year. Some experts expect this growth trend to continue to an ultimate 80% replacement of Types 301 and 302. With stainless steel production outrunning increasing nickel output, now is a good time for the designer to review

LOW-NICKEL, AUSTENITIC STAINLESS STEELS

L. F. SPENCER, *Consultant*
West Allis, Wisconsin

TEXT BEGINS ON NEXT PAGE . . . . .

Although the government intends to cease adding to stockpiles of nickel, this element will continue in short supply because of continuing development research and demand for alloys containing high percentages of nickel. There are two other factors which will insure continued interest in chromium-nickel-manganese compositions. First, these relatively new alloys have proved comparable to the chromium-nickel austenitic materials in fabrication and corrosion-resistant characteristics in the manufacture of consumer products. Second, the reduction of nickel within these new alloys will permit about twice the tonnage when compared to the austenitic chromium-nickel alloys.

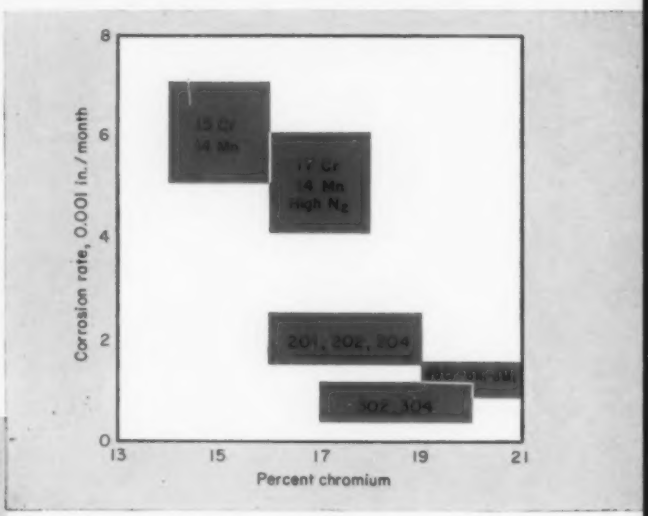
A variety of Cr-Ni-Mn compositions have been proposed, manufactured and used on an experimental basis. Many were abandoned because they were difficult to hot work and fabricate, or had limited corrosion resistance. Net result was the formal introduction in 1955 of AISI Types 201 and 202, both of which are now used extensively as replacements for the chromium-nickel stainless compositions. Further, lower carbon compositions in this same series, designated by Allegheny Ludlum as 204 and 204L, are being produced with reduced sensitivity to intergranular attack. An experimental composition of higher chromium content, designated as 20-6-8, is currently under development. Chemical compositions of these chromium-nickel-manganese alloys are given in Table I.

Fabrication and corrosion resistance are the two most important factors in any decision to use the Cr-Ni-Mn compositions: Experience to date has shown that they can be worked equally as well as the Cr-Ni stainless steels with but minor changes in technique. Nitrogen helps to maintain an austenitic structure, and manganese retards transformation during cold working. The powerful influence of nitrogen is evident in the small quantity required to replace nickel.

Table 1—Typical Analyses of Chromium-Nickel-Manganese Austenitic Stainless Steels

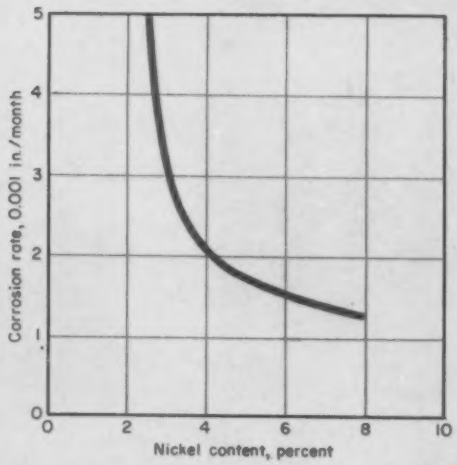
Designation	Composition, %				
	Carbon	Manganese	Chromium	Nickel	Nitrogen
CM	0.15 Max.	13.0/18.0	14.0/17.0	1.0 Max.	0.25 Max.
201	0.15 Max.	5.5/7.5	16.0/18.0	3.5/5.5	0.25 Max.
202	0.15 Max.	7.5/10.0	17.0/19.0	4.0/6.0	0.25 Max.
204	0.08 Max.	7.5/10.0	17.0/19.0	4.0/6.0	0.25 Max.
204L	0.03 Max.	7.5/10.0	17.0/19.0	5.0/7.0	0.25 Max.
20–6–8	0.10 Max.	7.0/9.0	19.0/21.0	5.0/7.0	0.20/0.35

Note: CM is the original composition used at the time 1.0% nickel maximum was required for civilian consumption; Types 201 and 202 are standard AISI analyses; Types 204 and 204L, although not standard AISI grades, are produced with lower carbon; alloy 20–6–8 is still in the experimental stage.



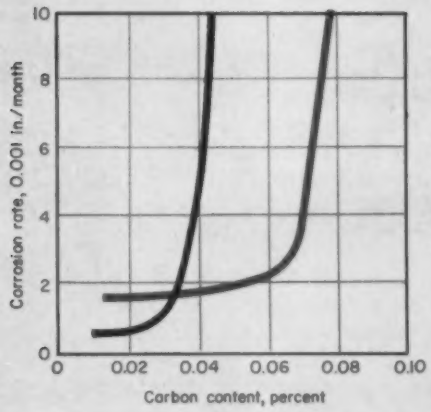
1 Influence of Cr and Ni . . .

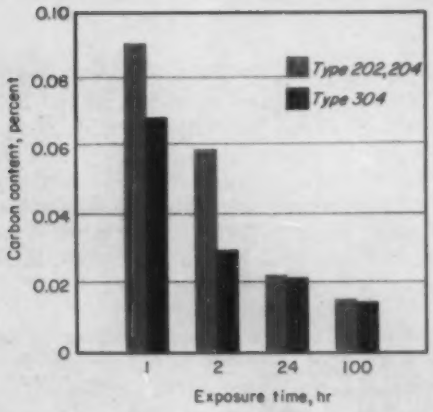
on corrosion rate of austenitic stainless steels. Addition of nickel, as in "200" series steels is more effective than chromium in reducing attack by boiling 65% nitric acid.



5 Sharp reduction . . .

in corrosion rate for 17Cr-10 Mn steel occurs when nickel content is increased from 2 to 4%. ▶





3 Maximum allowable . . .

carbon content can be increased over straight Cr-Ni steels because Cr-Ni-Mn steels are less susceptible to intergranular attack through carbide precipitation. Here, corrosion rates in boiling 65% nitric acid are compared after 2-hr exposure to 1200 F.

4 Shorter thermal exposure . . .

increases maximum allowable carbon content for prevention of intergranular corrosion. Cr-Ni steels have much higher carbon "immunity" level" than Cr-Ni steels for short exposure times as in welding.

CORROSION

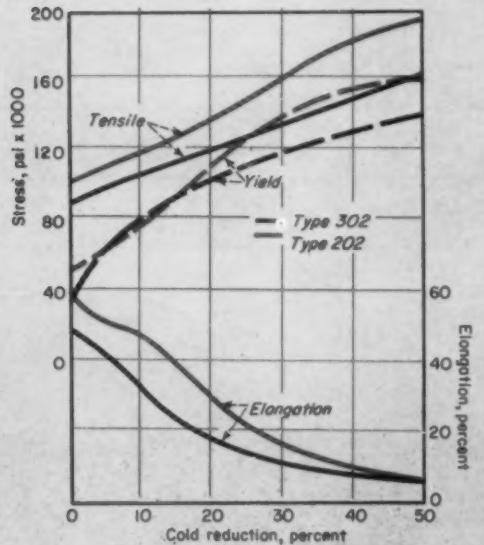
The standard "200" series of alloys have adequate corrosion resistance in atmospheric environments and in many media classified as moderately corrosive. However, where severe corrosive conditions are encountered, as exemplified in chemical industry applications, they are considered to be inferior to the chromium-nickel stainless compositions.

Chromium promotes and nickel stabilizes the protective film which enables the chromium-nickel stainless steels to resist highly corrosive environments. Of the two, nickel is more important for good corrosion resistance, as shown in Fig. 1 for boiling 65% nitric acid. Starting with 15 Cr-14 Mn, addition of chromium to 17 Cr reduces corrosion rate about 15%; addition of nickel to about 5 Ni in the "200" series cuts the rate 65%.

Importance of nickel is further indicated by Fig. 2 where a sharp reduction in attack rate occurs for "200" type 17 Cr-10 Mn steel with an increase in nickel from 2 to 4%. To improve corrosion resistance, Allegheny Ludlum has developed an experimental alloy designated 20-6-8. This alloy, which has an increase chromium content at the expense of manganese, has better resistance to localized attack in severe corrosive environments than the "200" series.

Intergranular attack in austenitic steels by carbide precipitation is often caused by fusion welding and stress relieving. One advantage of the "200" Cr-Ni-Mn steels is that they are less susceptible to this difficulty. As shown by Fig. 3, they are resistant to intergranular attack after prolonged exposure to boiling 65 %nitric acid up to about 0.06% carbon while type 304 requires a carbon content no more than 0.03% or below to be immune to this type of corrosion. This "immunity level" for carbon increases as temperature exposure time shortens, Fig. 4, and the Cr-Ni-Mn steels have a much higher permissible carbon level for short exposures than the straight Cr-Ni steels.

Thus, in welding or other conditions of short exposure Cr-Ni-Mn compositions can contain carbon up to 0.06% without danger of intergranular attack. However, in applications of any duration within the intergranular carbide range, 800-1650 F, the carbon should be below 0.03%. It is for this type of service that 204L has been developed.



FABRICATION

Types 201 and 202 are harder and have higher yield strengths, Fig. 5, than Types 301 and 302. Fully annealed

5 Effect of . . .

◀work hardening on mechanical properties of Cr-Ni-Mn stainless steels compared to straight Cr-Ni analyses. Note the higher elongations for the "200" series steels, along with high tensile strengths, for all levels of cold reduction.

201 strip has a yield of 50,000 psi and a Rockwell hardness of B92 as compared to 35,000 psi and B85 for Type 301. Similarly, Type 202 has a 50,000 psi yield and a B90 hardness as compared to a 35,000 psi and B85 for 302. Even with higher strength, ductility of the Cr-Ni-Mn steels is comparable to the chromium-nickel analyses. Work hardening properties for Type 202, the general purpose Cr-Ni-Mn alloy, are compared in more detail to Type 302 stainless in Fig. 5.

Structural parts such as truck body stiffeners can be formed from Type 201 as easily as from Type 301. It is not used extensively for severe forming operations, such as deep drawing where two or more successive operations are required because it tends to wrinkle. However, the high elongation values for Type 201, even in the harder tempers, permit bending or stretch forming. Types 202 and 204 will undergo more severe forming using procedures for Types 302 and 304. For all the Cr-Ni-Mn alloys, higher hold-down pressures are required to minimize wrinkling.

As with the chromium-nickel stainless steels, the usual procedure in deep drawing is to obtain the maximum reduction possible in a single stroke of the press rather than a series of successive small reductions prior to the regenerative anneal. The preference of a slow drawing speed is based on the ability of these austenitic materials to realize a more uniform elongation over the entire area subjected to the deformation force. Difficulty in working the "200" series steels to close tolerances may be minimized by cold sizing.

ANNEALING

Parts made from austenitic steels by repeated cold working require regenerative anneals between stages. Because the chromium-nickel-manganese compositions scale more rapidly, annealing temperature is 50-100 F lower than that used for the chromium-nickel steels. Normal procedure is to anneal at 1850-1950 F for one hour per every inch of thickness, followed by either a water or an air quench depending upon the gage of the material annealed. The quench must be sufficiently rapid to avoid re-precipitation of harmful carbides which adversely affect formability as well as corrosion resistance.

BEND RADII

Brake forming comparisons between "200" and "300" series show little difference. For example, in one com-

Table II—Recommended Minimum Bend Radii for Cr-Ni-Mn Stainless Steels

Yield Strength, psi	Bend Radius
55,000	½T–1½T
75,000	1 T–2½T
110,000	2 T–4½T
135,000	3½T–5½T
over 135,000	4½T–7 T

Table III—As-drawn Thickness and Hardness Measurements for 3-Quart Container

Position	Type 302		Type 202	
	Thickness, in.	Hardness	Thickness, in.	Hardness
Top Edge	0.023	Rc 36	0.027	Rc 43
Top Side	0.020	Rc 32	0.026	Rc 38
Middle Side	0.019	Rc 29	0.024	Rc 36
Lower Side	0.019	Rc 20	0.023	Rc 29
Corner	0.032	Rb 85	0.037	Rb 97
Bottom	0.032	Rb 80	0.040	Rb 95

6 Comparison of . . .

Electric stove burner supports stamped from Types 301 (right) and 201 (left) stainless. Deep dies were required to obtain equivalent clarity to supports produced from Type 301. Tuttle and Kift Co.

7 Tank for . . .

Coca-Cola (Pre-Mix) made from "200" series stainless steel by Alloy Products Corp. All fabricating procedures are identical with those used on "300" series tanks.

pany forming shapes of Types 201 and 301, operators were unable to distinguish the two types when they were intermixed in normal production. The recommended radii in Table II for Cr-Ni-Mn steels of various yield strengths can be used as a guide for brake, draw-bench or roll forming. In some cases, smaller radii can be used.

Specialty processes such as the Guerin and Hydroform processes. Marforming and stretch-forming depend upon material ductility. Because ductility of Cr-Ni-Mn steel is close to that of the straight Cr-Ni varieties, no changes in these techniques are required. All of these processes are characterized by relatively low cost tooling which has made them particularly adaptable for low production runs, or where frequent changes in design are encountered.

PRESS FORMING

Both shallow and deep-drawn parts are straightforwardly made with the "200" series steels. Type 201 is used for shallow draw work, whereas, Type 202 is preferred for the deeper and more difficult draw-pieces. Press-forming identical parts of Types 202 and 302 utilize the same forming sequence without additional investment in tooling. The only variation in procedure is that the hold-down pressure during high reduction draws has to be increased due to the higher strength values and slightly greater work hardening characteristics of the chromium-nickel-manganese analyses.

Embossing stamped Cr-Ni-Mn parts requires slightly deeper dies for identical clarity obtainable with Cr-Ni steels. For example, the electric stove burner supports in Fig. 6, which are sized, embossed and trimmed in one operation, had a clear image when made from Type 301 stainless. Clarity in the deepest areas was lost when material was changed to Type 201; however, further raising of the die corrected the difficulty.

A practical method of comparing work hardening rates is to obtain hardness and thickness measurements at selected points within a drawn piece. Such a comparison is made in Table III for a 3-quart cooking utensile made of Types 302 and 202 stainless steels. The two containers were made with identical procedures and tooling, except that higher hold-down pressures were required for Type 202. Note that for the Cr-Ni-Mn part a more uniform thickness is obtained throughout the utensile profile. (*continued p. 140*)

In spinning Cr-Ni-Mn parts from blanks or press formed shapes the material should be spun loosely over corners and then worked back to minimize strain hardening. All radii should be at a minimum of five times the metal thickness, and a narrow flange retained through final spinning to minimize edge cracking. When working from a blank, spinning speed is reduced to ½-¼ that used for copper parts.

WELDING

Chromium-nickel-manganese steels respond to the standard welding procedures in the same manner as the chromium-nickel stainless grades. Filler wire can be either conventional Type 308 or Cr-Ni-Mn composition matching the base plate. Electrodes of the latter type are currently available. Weld strength and ductility are comparable between the two base metal classes. Mechanical properties for welded Type 202 sheet and plate are given in Table IV and V. Low temperature impact values are included.

The greater resistance of the Cr-Ni-Mn steels to thermal sensitization for similar carbon content provides an added factor of safety in welded parts where solution heat treatment for optimum corrosion resistance is not required (see Fig. 3). However, if full corrosion resistance is required, use of the low carbon grades 204 and 204L will assure the absence of any harmful intergranular carbides.

EDITOR'S NOTE: Other important factors in stainless steel design are covered in the following recent articles:

"Thermal Stress Fatigue" June 1957 page 183. Higher operating temperatures accentuate premature failure in structural parts. A design criterion is presented for estimating the safe number of thermal cycles for any material. Data on Type 347 stainless is included.

"High Temperature Stainless" April 1957 page 135. Compared are three basic types of stainless for the temperature range 600 to 1400 F. Included are tensile, yield and rupture data on eight alloys, plus fabrication data.

"New Nickel-Free Stainless" December 1956 page 151. Presents data on austenitic stainless steel with nickel replaced by manganese and nitrogen to give improved strength and satisfactory formability.

"How to Work Stainless Steel," Design Digest, Mid-October 1956 page D9. Up-to-date information is presented on 31 standard stainless steel types, including mechanical and physical properties.

Table V—Typical Mechanical Properties for Welded Type 202 Stainless Plate

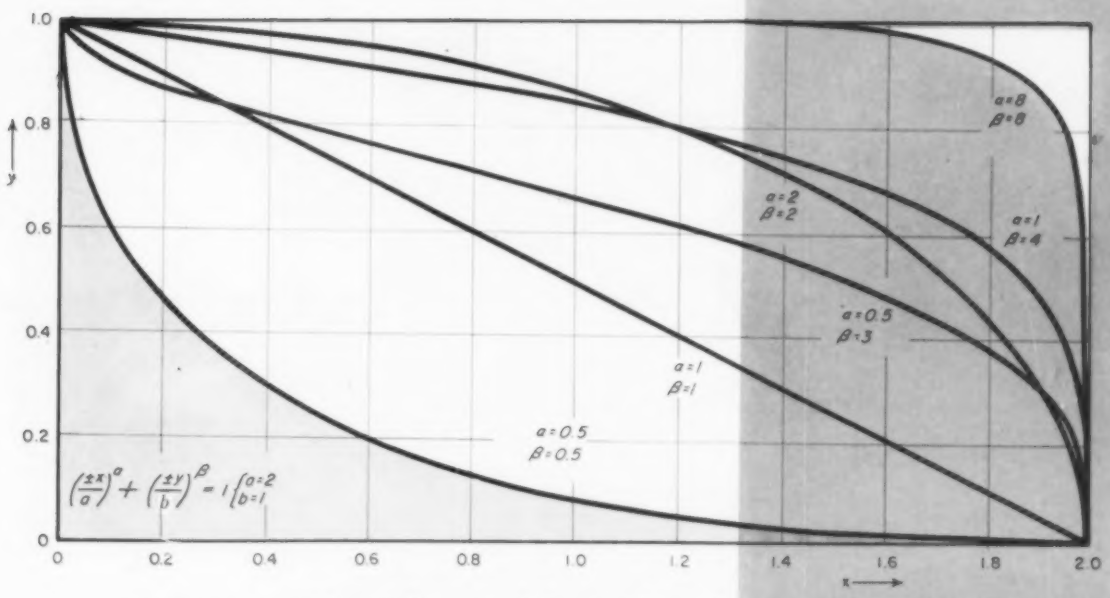
Condition	Yield Strength, psi	Tensile Strength, psi	Elongation, %	Charpy Impact in Weld, ft-lb/in. 68F	Charpy Impact in Weld, ft-lb/in. −320 F
As-welded [1]	63,600	101,800	48	53–55	35–40
Annealed [2]	47,200	95,400	60	65–66	43–51

Note 1: Inert arc welded.
Note 2: Annealed ½ hr at 1965 F after welding.

Table IV—Typical Mechanical Properties for Welded Type 202 Stainless Sheet

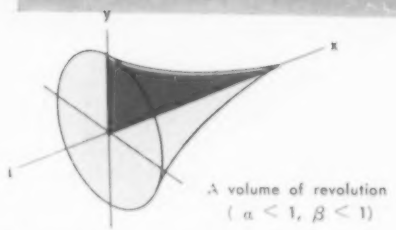
Condition	Specimen Position	Yield Strength, psi	Tensile Strength, psi	Elongation, %
0.052 in., Inert arc fusion weld	XA	57,900	107,900	53
	WA	58,300	109,700	54
	XB	47,700	105,700	59
	WB	46,000	102,600	54
0.052 in. Inert arc Type 308 filler wire	XA	62,200	116,200	59
	WA	65,600	116,900	58
	XB	46,600	106,700	56
	WB	47,400	100,900	41
0.140 in., metal arc Type 308 electrode	WA	56,600	103,000	53
	WB	51,900	97,100	28

Note: X-welded cross grain; A—test along weld; W—welded with grain; B—test across weld.



areas, centroids and inertias for a family of

ELLIPTIC-TYPE CLOSED CURVES



Fairings, enclosure shapes, and other two- and three-dimensional figures, can be analyzed with these versatile formulas. A simple method of calculating gamma functions simplifies their evaluation.

WILL J. WORLEY, *Associate Professor, Department of Theoretical & Applied Mechanics, University of Illinois, Urbana, Ill.*
FRED D. BREUER, *Aerodynamics Engineer, Convair, San Diego, Calif.*

Areas and volumes of ellipses and ellipsoids are easily calculated from their axis lengths by handbook formulas. However, a more general and often convenient form of elliptic curves may be represented by the relationship

$$\left(\frac{\pm x}{a}\right)^{\alpha}+\left(\frac{\pm y}{b}\right)^{\beta}=1 \qquad (1)$$

or for volumes

$$\left(\frac{\pm x}{a}\right)^{\alpha}+\left(\frac{\pm y}{b}\right)^{\beta}+\left(\frac{\pm z}{c}\right)^{\gamma}=1 \qquad (2)$$

Typical curves based on Eq (1) are drawn in Fig. 1 where only the first quadrant is shown. When the powers of x and y are even powers* (as in the case of the ellipse) both positive and negative values of x and y result in positive terms. In Eq (1) where α need not be equal to β and neither need be an integer, plus and minus signs must be included with the understanding that $(\pm x)$ and $(\pm y)$ are always positive. The curves shown in Fig. 1 may then be reflected as mirror images about both axes to give symmetrical closed curves.

SLOPE AND DEFLECTION

Solving for y in Eq (1) and differentiating, the slope is given by

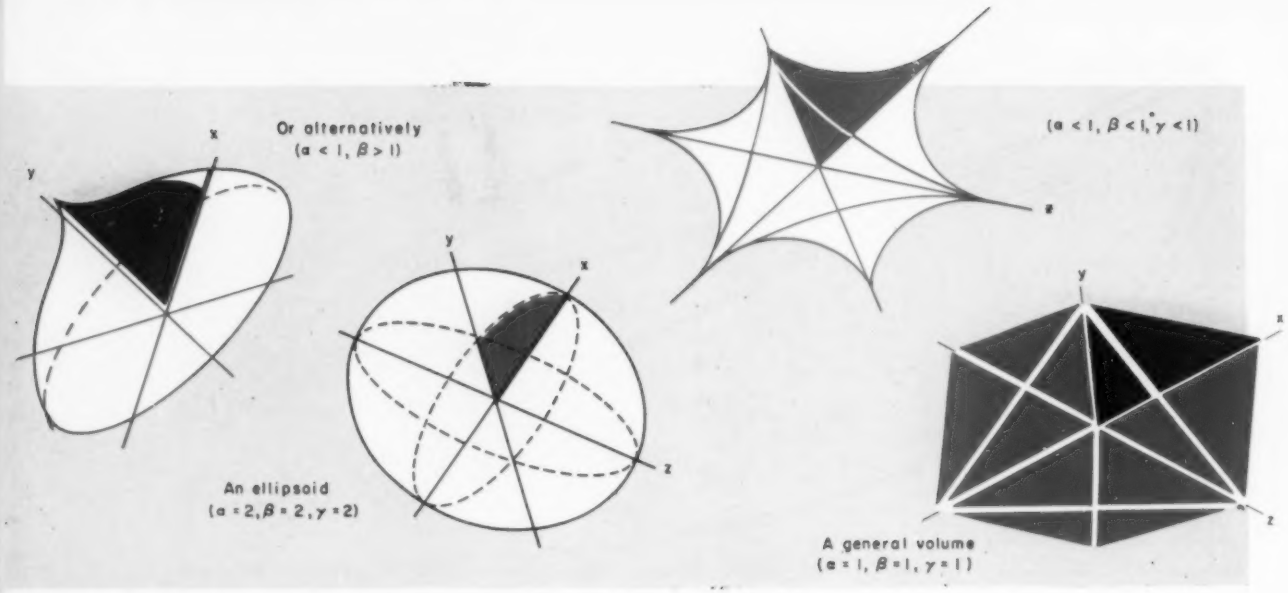
$$\frac{dy}{dx}=-\frac{\alpha b^{\beta}}{\beta a^{\alpha}}\,x^{(\alpha-1)}\,y^{(1-\beta)}$$

$$=-\frac{\alpha b}{\beta a^{\alpha}}\,x^{(\alpha-1)}\left[1-\left(\frac{x}{a}\right)^{\alpha}\right]^{(1/\beta-1)} \qquad (3)$$

At $x = 0$ the slopes are

α	$\frac{dy}{dx}$
>1	0
1	$-\frac{b}{\beta a}$
<1	∞

* Selichi, Higuchi, "On Some Closed Algebraic Curves and Their Application to Dynamical Problems," Part I, *Philosophical Magazine and Journal of Science*, Vol. 9, 7th Series, Jan 1930, pp. 184-190.



At $x = a$ the slopes are

β	$\frac{dy}{dx}$
>1	∞
1	$-\frac{ab}{a}$
<1	0

Setting the second derivative of y with respect to x equal to zero the inflection point is at

$$x = a\left[\frac{(\alpha - 1)\beta}{\alpha - \beta}\right]^{1/\alpha} \tag{4}$$

Inflection points exist only for the conditions $0<\beta<1$ with $\alpha>1$ or for $0<\alpha<1$ with $\beta>1$.

AREAS

Since a given curve encloses the same area in any quadrant, only the first quadrant need be considered and the $(\pm)$ notation of Eq (1) may be disregarded in calculating areas.

Transposing Eq (1) and substituting

$$A = \int_0^a y\,dx = b\int_0^a \left[1 - \left(\frac{x}{a}\right)^{\alpha}\right]^{1/\beta} dx \tag{5}$$

This equation is one of the type presented in Pierce, *A Short Table of Integrals*. Formula 482 reads

$$\int_0^1 u^{(m-1)}(1-u)^{(n-1)}\,dx = \frac{\Gamma(m)\,\Gamma(n)}{\Gamma(m+n)} \tag{6}$$

where $\Gamma(m)$, $\Gamma(n)$ and $\Gamma(m + n)$ represent gamma functions.

Let $$u = \left(\frac{x}{a}\right)^{\alpha}, \qquad \begin{cases} x = 0, & u = 0 \\ x = a, & u = 1 \end{cases}$$

$$du = \frac{\alpha}{a^{\alpha}}\,x^{(\alpha-1)}\,dx$$

$$dx = \frac{a^{\alpha}}{\alpha}\,x^{(1-\alpha)}\,du = \frac{a^{\alpha}}{\alpha}\,(au^{1/\alpha})^{(1-\alpha)}\,du$$

Substituting these relations into Eq (5) leads to

$$A = \frac{ab}{\alpha}\int_0^1 u^{(1/\alpha-1)}(1-u)^{1/\beta}\,du$$

$$= \frac{ab}{\alpha}\left[\frac{\left(\frac{1}{\alpha}\right)\Gamma\left(\frac{1}{\beta}+1\right)}{\Gamma\left(\frac{1}{\alpha}+\frac{1}{\beta}+1\right)}\right]$$

However, $\Gamma(n + 1) = n\Gamma(n)$ thus $\Gamma(1/\alpha) = \alpha\Gamma(1/\alpha + 1)$ or

$$A = ab\left[\frac{\Gamma\left(\frac{1}{\alpha}+1\right)\Gamma\left(\frac{1}{\beta}+1\right)}{\Gamma\left(\frac{1}{\alpha}+\frac{1}{\beta}+1\right)}\right] \tag{7}$$

GAMMA FUNCTIONS

Gamma functions are tabulated by Jahnke and Emde (*Tables of Functions with Formulae and Curves*), and Dwight (*Tables of Integrals and Other Mathematical Data*), and a clear treatment of the theory and application is given by Reddick and Miller (*Advanced Mathematics for Engineers*). However, a few definitions and functions are presented here to permit computation of areas for α or β equal to $\frac{1}{2}$, $\frac{3}{2}$, 1, 2, 3, . . . etc.

These relations follow

$$\Gamma(n + r) = (n + r - 1)(n + r - 2)\ldots(n)\Gamma(n)$$

for r a positive integer greater then unity and $n>0$,

$$\Gamma(n + 1) = n!$$

$$\Gamma(1/2) = \sqrt{\pi}$$

CENTROIDS AND MOMENTS OF INERTIA OF AREAS

The x—coordinate of the centroid of the first quadrant area may be obtained from the equation

$$A\bar{x} = \int_0^a xy\,dx = b\int_0^a x\left[1 - \left(\frac{x}{a}\right)^{\alpha}\right]^{1/\beta} dx \tag{8}$$

which is solved by using Eqs (6) and (7) to give

$$\bar{x} = \frac{a}{2}\left[\frac{\Gamma\left(\frac{2}{\alpha}+1\right)\Gamma\left(\frac{1}{\alpha}+\frac{1}{\beta}+1\right)}{\Gamma\left(\frac{1}{\alpha}+1\right)\Gamma\left(\frac{2}{\alpha}+\frac{1}{\beta}+1\right)}\right] \quad (9)$$

The equation for $\bar{y}$ is obtained by an interchange of a with b and α with β.

An example showing how this equation, and others that follow, may be evaluated using relations in the preceding section may be helpful. A solution for x with $\alpha = \frac{1}{2}$ and $\beta = \frac{2}{3}$ is

$$\bar{x} = \frac{a}{2}\left[\frac{\Gamma(5)\Gamma(4.5)}{\Gamma(3)\Gamma(6.5)}\right]$$

$$= \frac{a}{2}\left[\frac{(4\times3\times2\times1)(3.5\times2.5\times1.5\times0.5\times\sqrt{\pi})}{(2\times1)(5.5\times4.5\times3.5\times2.5\times1.5\times0.5\times\sqrt{\pi})}\right]$$

$$= 0.242a$$

The moment of inertia about the x axis of the area in the first quadrant may be written as

$$I_x = 1/3\int_0^a y^3\,dx = \frac{b^3}{3}\int_0^a\left[1-\left(\frac{x}{a}\right)^\alpha\right]^{3/\beta}dx \quad (10)$$

Evaluated by Eq (6) this becomes

$$I_x = \frac{ab^3}{3}\left[\frac{\Gamma\left(\frac{1}{\alpha}+1\right)\Gamma\left(\frac{3}{\beta}+1\right)}{\Gamma\left(\frac{1}{\alpha}+\frac{3}{\beta}+1\right)}\right] \quad (11)$$

A similar expression for I_y results from the interchange of a with b and α with β.

VOLUMES OF REVOLUTION

The volume of revolution obtained by rotating the first quadrant of the curve described by Eq (1) about the x-axis is determined by a solution of the expression

$$V_x = \int_0^a \pi y^2\,dx = \pi b^2\int_0^a\left[1-\left(\frac{x}{a}\right)^\alpha\right]^{2/\beta}dx \quad (12)$$

Using the procedure which was used in solving the area integral, the volume is

$$V_x = \pi ab^2\left[\frac{\Gamma\left(\frac{1}{\alpha}+1\right)\Gamma\left(\frac{2}{\beta}+1\right)}{\Gamma\left(\frac{1}{\alpha}+\frac{2}{\beta}+1\right)}\right] \quad (13)$$

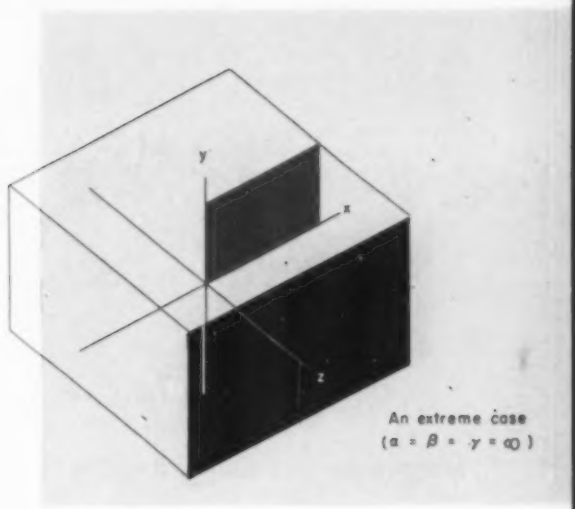
In like manner, the volume of revolution of the first quadrant portion of the curve with respect to the y-axis is

$$V_y = \pi a^2 b\left[\frac{\Gamma\left(\frac{2}{\alpha}+1\right)\Gamma\left(\frac{1}{\beta}+1\right)}{\Gamma\left(\frac{2}{\alpha}+\frac{1}{\beta}+1\right)}\right] \quad (14)$$

CENTROIDS OF VOLUMES OF REVOLUTION

The x coordinate of the centroid of the volume of revolution, may be determined by solving for x in the expression

$$V\bar{x} = \int_0^a \pi y^2 x\,dx = \pi b^2\int_0^a\left[1-\left(\frac{x}{a}\right)^\alpha\right]^{2/\beta}x\,dx \quad (15)$$



An extreme case
($\alpha = \beta = \gamma = \infty$)

Proceeding as before, and making use of Eq (13)

$$\bar{x} = \frac{a}{2}\left[\frac{\Gamma\left(\frac{2}{\alpha}+1\right)\Gamma\left(\frac{1}{\alpha}+\frac{2}{\beta}+1\right)}{\Gamma\left(\frac{1}{\alpha}+1\right)\Gamma\left(\frac{2}{\alpha}+\frac{2}{\beta}+1\right)}\right] \quad (16)$$

Because of symmetry, the y coordinate is equal to zero.

MOMENTS OF INERTIA OF VOLUMES OF REVOLUTION

The moment of inertia about the x-axis of this volume of revolution requires a solution of the expression

$$I_x = \frac{\pi}{2}\int_0^a y^4\,dx = \frac{\pi b^4}{2}\int_0^a\left[1-\left(\frac{x}{a}\right)^\alpha\right]^{4/\beta}dx \quad (17)$$

Application of Eq (6) yields

$$I_x = \frac{\pi ab^4}{2}\left[\frac{\Gamma\left(\frac{1}{\alpha}+1\right)\Gamma\left(\frac{4}{\beta}+1\right)}{\Gamma\left(\frac{1}{\alpha}+\frac{4}{\beta}+1\right)}\right] \quad (18)$$

Similarly, using the parallel axis theorem, the moment of inertia about the y-axis is found to be

$$I_y = \pi\int_0^a y^2x^2\,dx + \frac{\pi}{4}\int_0^a y^4\,dx$$

$$= \pi ab\left\{\frac{a^2b}{3}\left[\frac{\Gamma\left(\frac{3}{\alpha}+1\right)\Gamma\left(\frac{2}{\beta}+1\right)}{\Gamma\left(\frac{3}{\alpha}+\frac{2}{\beta}+1\right)}\right]\right.$$

$$\left.+\frac{b^3}{4}\left[\frac{\Gamma\left(\frac{1}{\alpha}+1\right)\Gamma\left(\frac{4}{\beta}+1\right)}{\Gamma\left(\frac{1}{\alpha}+\frac{4}{\beta}+1\right)}\right]\right\} \quad (19)$$

MORE COMPLEX VOLUMES

In determining the volume enclosed by the surface represented by Eq (2), the expression for the area in

Eq (5) may be used. The volume in the four octants for x positive becomes,

$$V = 4\int_0^a y\Big|_{x=0} z\Big|_{y=0} \left[\frac{\Gamma\left(\frac{1}{\beta}+1\right)\Gamma\left(\frac{1}{\gamma}+1\right)}{\Gamma\left(\frac{1}{\beta}+\frac{1}{\gamma}+1\right)}\right] dx$$

$$= 4bc\left[\frac{\Gamma\left(\frac{1}{\beta}+1\right)\Gamma\left(\frac{1}{\gamma}+1\right)}{\Gamma\left(\frac{1}{\beta}+\frac{1}{\gamma}+1\right)}\right]$$

$$\times\int_0^a \left[1-\left(\frac{x}{a}\right)^\alpha\right]^{\frac{1}{\beta}+\frac{1}{\gamma}} dx \qquad (20)$$

Solution of this integral reduces the expression to

$$V = 4abc\left[\frac{\Gamma\left(\frac{1}{\alpha}+1\right)\Gamma\left(\frac{1}{\beta}+1\right)\Gamma\left(\frac{1}{\gamma}+1\right)}{\Gamma\left(\frac{1}{\alpha}+\frac{1}{\beta}+\frac{1}{\gamma}+1\right)}\right] \qquad (21)$$

CENTROIDS OF COMPLEX VOLUMES

A similar integral appears in the equation for the x coordinate of the centroid of this general volume,

$$V\bar{x} = \int_0 y\Big|_{x=0} z\Big|_{y=0} \left[\frac{\Gamma\left(\frac{1}{\beta}+1\right)\Gamma\left(\frac{1}{\gamma}+1\right)}{\Gamma\left(\frac{1}{\beta}+\frac{1}{\gamma}+1\right)}\right] x dx \qquad (22)$$

Solving for x and simplifying,

$$\bar{x} = \frac{a}{2}\left[\frac{\Gamma\left(\frac{2}{\alpha}+1\right)\Gamma\left(\frac{1}{\alpha}+\frac{1}{\beta}+\frac{1}{\gamma}+1\right)}{\Gamma\left(\frac{1}{\alpha}+1\right)\Gamma\left(\frac{2}{\alpha}+\frac{1}{\beta}+\frac{1}{\gamma}+1\right)}\right] \qquad (23)$$

MOMENTS OF INERTIA OF COMPLEX VOLUMES

The moment of inertia about the x-axis of the general volume in the four octants for x positive can be evaluated by selecting differential volume slices parallel to the yz plane and then integrating over the range for x. This selection permits the use of the polar moment of inertia relationship for a plane mass,

$$I_x = I_y + I_z \qquad (24)$$

This procedure, facilitated by an equation similar to Eq (11), allows I_x to be written as

$$I_x = \frac{4}{3}\int_0^a y\Big|_{x=0} z^3\Big|_{y=0} \left[\frac{\Gamma\left(\frac{1}{\beta}+1\right)\Gamma\left(\frac{3}{\gamma}+1\right)}{\Gamma\left(\frac{1}{\beta}+\frac{3}{\gamma}+1\right)}\right] dx$$

$$+\frac{4}{3}\int_0^a y^3\Big|_{x=0} z\Big|_{y=0} \left[\frac{\Gamma\left(\frac{3}{\beta}+1\right)\Gamma\left(\frac{1}{\gamma}+1\right)}{\Gamma\left(\frac{3}{\beta}+\frac{1}{\gamma}+1\right)}\right] dx \qquad (25)$$

Substituting y and z in terms of x and using Eq (6) the following values are obtained

$$I_x = \frac{4}{3}abc\left\{b^2\left[\frac{\Gamma\left(\frac{1}{\alpha}+1\right)\Gamma\left(\frac{3}{\beta}+1\right)\Gamma\left(\frac{1}{\gamma}+1\right)}{\Gamma\left(\frac{1}{\alpha}+\frac{3}{\beta}+\frac{1}{\gamma}+1\right)}\right]\right.$$

$$\left.+c^2\left[\frac{\Gamma\left(\frac{1}{\alpha}+1\right)\Gamma\left(\frac{1}{\beta}+1\right)\Gamma\left(\frac{3}{\gamma}+1\right)}{\Gamma\left(\frac{1}{\alpha}+\frac{1}{\beta}+\frac{3}{\gamma}+1\right)}\right]\right\} \qquad (26)$$

Similarly

$$I_y = \frac{4}{3}abc\left\{a^2\left[\frac{\Gamma\left(\frac{3}{\alpha}+1\right)\Gamma\left(\frac{1}{\beta}+1\right)\Gamma\left(\frac{1}{\gamma}+1\right)}{\Gamma\left(\frac{3}{\alpha}+\frac{1}{\beta}+\frac{1}{\gamma}+1\right)}\right]\right.$$

$$\left.+c^2\left[\frac{\Gamma\left(\frac{1}{\alpha}+1\right)\Gamma\left(\frac{1}{\beta}+1\right)\Gamma\left(\frac{3}{\gamma}+1\right)}{\Gamma\left(\frac{1}{\alpha}+\frac{1}{\beta}+\frac{3}{\gamma}+1\right)}\right]\right\} \qquad (27)$$

and

$$I_z = \frac{4}{3}abc\left\{a^2\left[\frac{\Gamma\left(\frac{3}{\alpha}+1\right)\Gamma\left(\frac{1}{\beta}+1\right)\Gamma\left(\frac{1}{\gamma}+1\right)}{\Gamma\left(\frac{3}{\alpha}+\frac{1}{\beta}+\frac{1}{\gamma}+1\right)}\right]\right.$$

$$\left.+b^2\left[\frac{\Gamma\left(\frac{1}{\alpha}+1\right)\Gamma\left(\frac{3}{\beta}+1\right)\Gamma\left(\frac{1}{\gamma}+1\right)}{\Gamma\left(\frac{1}{\alpha}+\frac{3}{\beta}+\frac{1}{\gamma}+1\right)}\right]\right\} \qquad (28)$$

SPECIAL CASES

Several areas and volumes of interest result for certain values of the exponents, α, β and γ. In Eq (1) (considering the first quadrant only), for $\alpha = \beta = 1$ the area is a triangle, for $\alpha = \beta = 2$ an ellipse, and as α and β each approach infinity a rectangle results. Revolution of these special areas generate respectively a right circular cone, an ellipsoid of revolution, and a right circular cylinder. In Eq (2) for $\alpha = \beta = \gamma = 1$ the volume is a pyramidal surface, for $\alpha = \beta = \gamma = 2$ an ellipsoid, and as α, β, and γ each approach infinity a right parallelepiped is formed

EDITOR'S NOTE: As designs become more complex the more advanced mathematical tools of analysis can greatly simplify tedious calculations.

A published article, "Mathematical Tables — a bibliography," July 1957, page 193, is an annotated list of tables of mathematical functions useful in the solution of engineering problems.

"More Books (on mathematics)," April 1957, page 192, was a short list of 14 super-selected texts for the engineer's bookshelf.

"Computers Simplify Design of Polynomial Cams," March 1957, page 196. Equations for specifying cam contours; curve fitting methods; comparison of polynomial with common cam curves; use of computers for cam problems.

Billet . . .
(left) and extruded part (right) made by backward extrusion. Finished part requires additional extruding operations.

When to Use Cold Extrusion for STEEL PARTS

CHARLES B. GRACE, *President*
Heintz Mfg. Co., Philadelphia, Pa.

In designing shafts, cylinders and other parts that have a relatively simple shape and an axis of symmetry, cold extrusion is an economical method of forming a variety of carbon and alloy steels.

The process depends on the ability of these metals to undergo considerable plastic deformation under compression at room temperature. Main advantages are low cost and high production rate, minimum scrap, and an increase in mechanical properties of the material.

HOW THE PROCESS WORKS

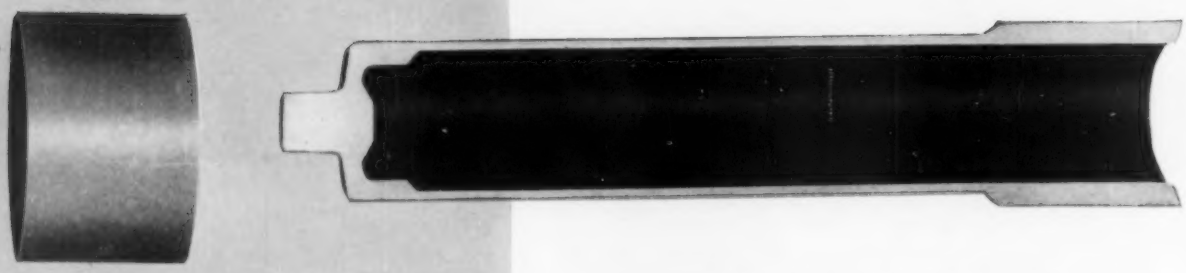
A cold-extruded part starts out as a billet cut from commercial bar or ingot. The billet is placed in a high-speed press and squeezed between a punch and a die, filling the cavity between them. If the main flow of the metal is in the general direction in which the punch travels, the process is called forward extrusion and the part usually has a solid cross section. When the flow of metal is primarily in a direction opposite to the punch, the process is called backward extrusion and the part is largely hollow or cup-shaped. The two processes can be used in combination to produce a wide variety of shapes. In forming, the original section may be reduced as much as 85%.

As tool cost is an important factor in economical use of the process, lowest cost is obtained when the quantity needed is just equal to die life. Die life varies with type of steel used in making the part. Because the cycle is relatively short (only a few seconds) and set-up time is appreciable, a long run (in thousands) helps to reduce unit cost.

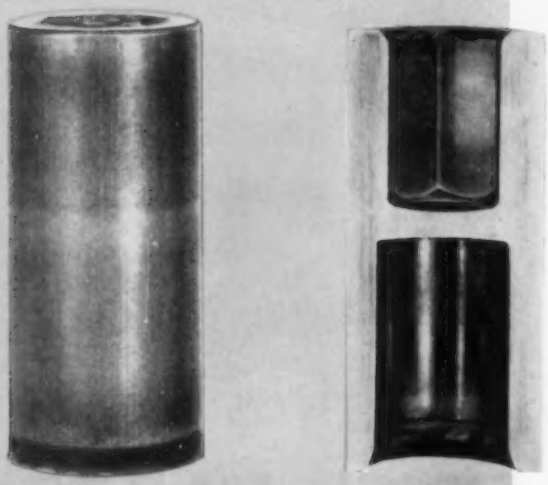
Uniform properties of rolled stock from which the billets are cut, coupled with identical type and amount of deformation in extrusion give high property reproducibility. Economical use of materials permits cutting down of inventory required for a given production rate.

CHOICE OF MATERIALS

Physical properties obtained, Table I, are much higher than for annealed materials. This is the result of cold working and elongation of grains into flow lines. On mild steel, yield strengths will range from 80,000 to 160,000 psi without any heat treatment. This increase in strength permits use of mild-steel extrusions where



A 2.2-lb billet . . .
(left) cut from AISI 1015 steel bar is cold extruded to produce this 2-lb hydraulic cylinder (right). Design originally was made from tubing and two hot-forged end caps brazed together and machined. Cold extruding cut the cost 25%.



Several internal shapes . . .
may be combined, as in this lower control-arm housing for torsion-bar suspension. Housing is 1035 carbon steel and requires no heat treatment. Cold extrusion saves 25% of former cost.

higher-carbon or low-alloy steels would be required for a part made by forging, casting or machining. Or the higher strength may permit a reduction in weight or size.

Other extrudable materials show a similar increase in properties, such as for alloys in the AISI 4000, 4100, 5100, 6100, 8600, and 8700 classes, and the higher carbon steels.

SHAPE OF EXTRUDED PARTS

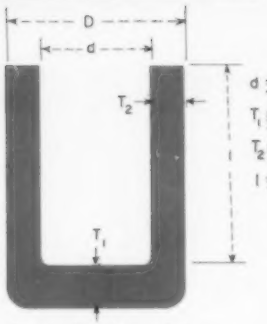
Cold extrusion is used in the production of both solid and hollow geometric shapes with an axis of symmetry, such as stepped shafts and cylindrical hollow bodies with or without internal or external bosses, webs, splines and gear teeth. Usual parts are from 1- to 6-in. OD and up to 4-in. ID, with a length up to 20 in. Maximum weight is about 15 lb.

One-piece steel extrusions can be designed to replace assemblies, such as a combination of a forging with tubular members, or stampings, screw machine parts and heavy walled tubing. Thin-wall cylinders can be made with heavy bases, flanges or webs, or with varying wall thickness.

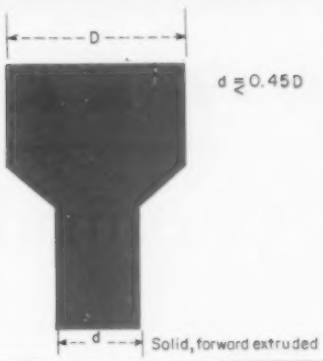
Tolerances on diameter and length range from 0.003 in. for small parts to 0.010 in. for the larger parts. Concentricity can be maintained within 0.008 in. Surface finish ranges from 10 to 50 microinches. Mechanical properties are uniform from part to part, and die detail reproduces well.

Table I. Effect of Cold Extrusion on Yield Strength and Elongation of Steel

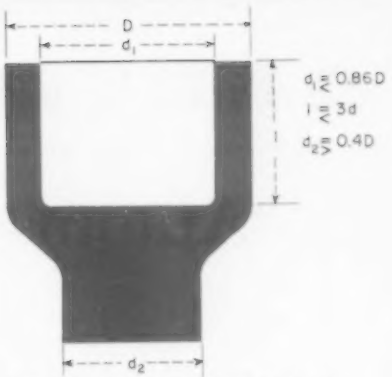
Type	Yield Strength, psi		Elongation, %	
	Annealed	Cold Extruded	Annealed	Cold Extruded
1010	24,000	117,400	40	13.5
1018	28,850	133,500	39	12.0
1030	49,500	161,000	31	9.0
1035	50,000	160,500	30	5.5
4130	52,250	139,000	28	14.5
4140	60,400	159,000	26	12.0
5130	55,000	115,500	28	12.0
6120	55,000	115,000	32	14.0
8620	55,875	125,650	31	14.0
8630	54,000	166,350	29	12.0
8730	65,000	145,000	25	17.5



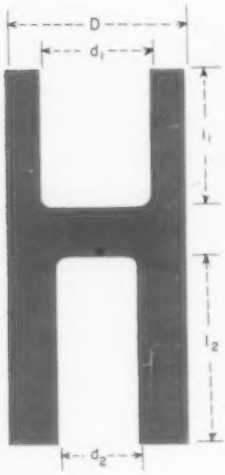
Cup, backward extruded



Solid, forward extruded

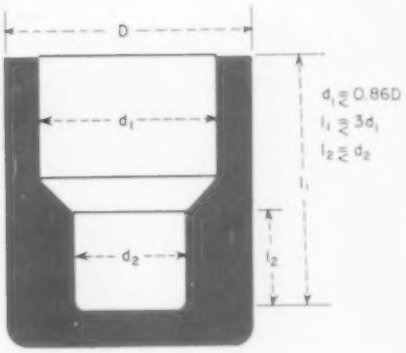


Cup, backward extruded with outside steps



Double cup, backward extruded

Double end solid, forward extruded in one operation



Cup, backward extruded with inside steps

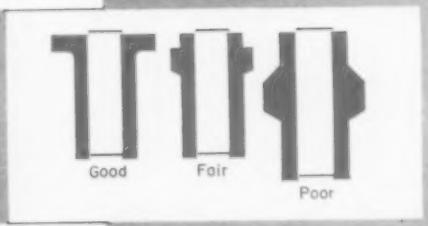
EDITOR'S NOTE—The Ugine-Sejournet process for hot extrusion of steel using glass lubrication was reported in "Extruded Low Carbon Steels," July 1955 page 129.

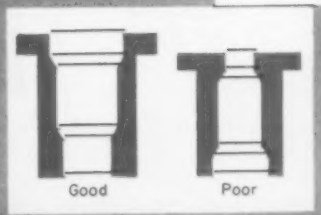
"Aluminum and Magnesium Extrusions," October 1956 page 200, describes shapes produced by forward extrusion of the softened metals. "Aluminum Extrusions from the Heavy Press Program," August 1955 page 150, tells how larger sections and longer lengths can be obtained.

"Impact Extrusions," April 1954 page 173, gives typical examples of aluminum parts produced by the process. Materials, properties, sizes, tolerances, surface finish and use of steel inserts are described in "A Closer Look at Impact Extrusions," July 1954 page 129.

Passage from one internal diameter to other should be gradual to facilitate metal flow.

Shoulders should be located at one end whenever possible.

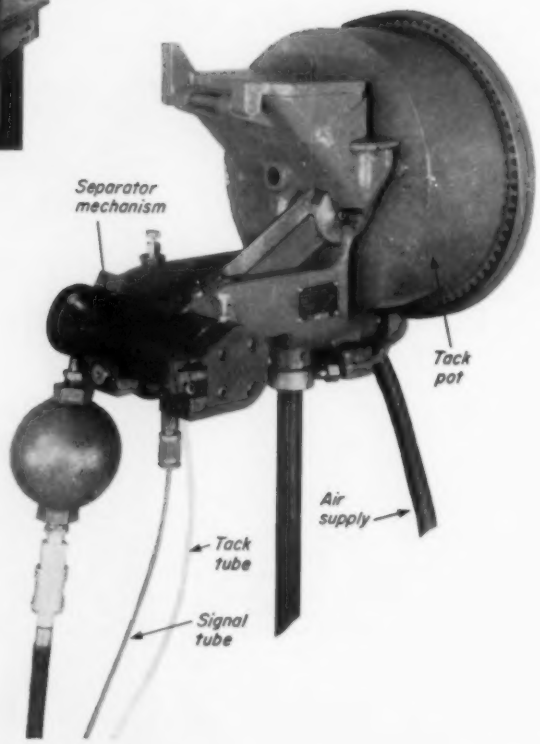




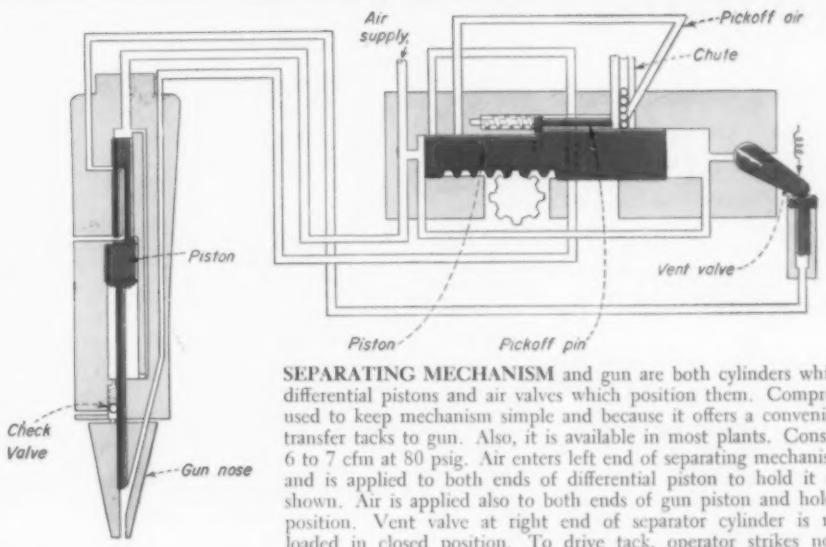
Inside and outside steps should progress in size in the same direction if possible, to minimize difference in wall size and produce more uniform flow lines.

Automatic Pneumatic Tacker

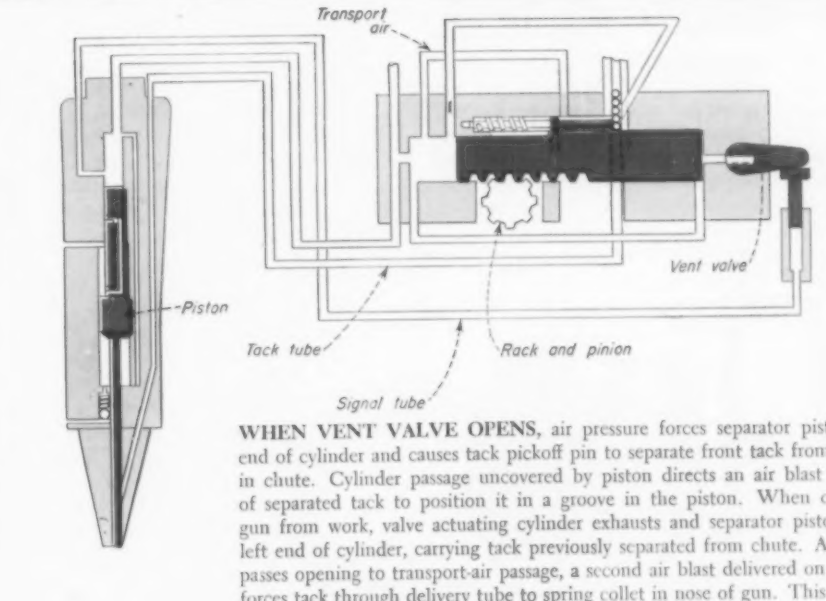
Compressed air transports tacks from a hopper and feeding mechanism to a portable gun and then drives them into the work. Made by United Shoe Machinery Corp. of Boston, this machine is the first automatic equipment designed to drive low-cost tacks at high speed. Gun weighs 3 lb and can handle machine-grade tacks in sizes from $\frac{1}{4}$ to $\frac{3}{4}$ in. at rates over 300 per minute. Major design problems included selecting material for flexible hose which transports tacks from feeder to gun and controlling air pulses which position and transport tacks.



PRINCIPAL COMPONENTS OF TACKER are tack pot, separating mechanism, gun and air circuits. Tack pot, which holds up to 8000 tacks, rotates about a horizontal axis and feeds tacks down a chute to tack separating mechanism. This mechanism picks one tack at a time from the chute and feeds it to gun through a 6-ft nylon hose. Machine handles 3 sizes of tacks without changing parts. By pressing gun against work, operator triggers air driven plunger which drives tack. This power tacker finds wide application in the upholstery industry where work has been done by labor skilled in spitting tacks on magnetic hammers. Also, using a magnetic hammer, a good worker can only drive around 60 tacks per minute. Portable devices were staple hammers which required frequent loading. Pneumatic tacker has larger tack capacity, raises possible production rates and avoids health hazards.



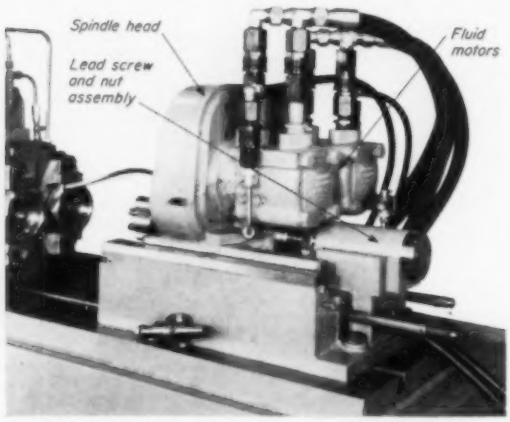
SEPARATING MECHANISM and gun are both cylinders which contain differential pistons and air valves which position them. Compressed air is used to keep mechanism simple and because it offers a convenient way to transfer tacks to gun. Also, it is available in most plants. Consumption is 6 to 7 cfm at 80 psig. Air enters left end of separating mechanism cylinder and is applied to both ends of differential piston to hold it in position shown. Air is applied also to both ends of gun piston and holds it in up position. Vent valve at right end of separator cylinder is now spring loaded in closed position. To drive tack, operator strikes nose of gun against work. This action unseats a ball check valve and exhausts lower side of gun piston. Air pressure now forces piston and drive rod down, pushing tack into work. Simultaneously, air enters signal tube and opens vent valve in separator cylinder.



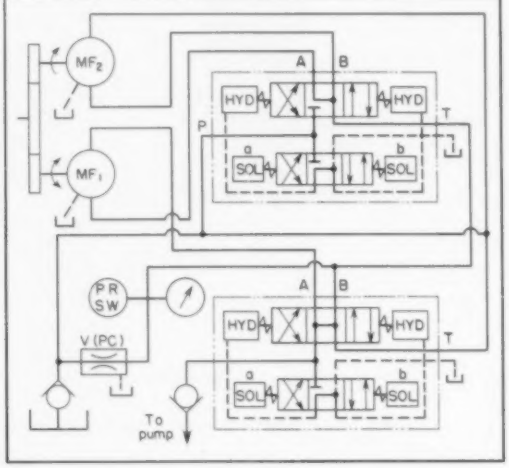
WHEN VENT VALVE OPENS, air pressure forces separator piston to right end of cylinder and causes tack pickoff pin to separate front tack from other tacks in chute. Cylinder passage uncovered by piston directs an air blast against side of separated tack to position it in a groove in the piston. When operator lifts gun from work, valve actuating cylinder exhausts and separator piston moves to left end of cylinder, carrying tack previously separated from chute. As piston slot passes opening to transport-air passage, a second air blast delivered on top of tack, forces tack through delivery tube to spring collet in nose of gun. This cycle occurs each time gun is triggered. Sequencing air pulses and tack motions was a major design problem. Also, venting was critical where air blasts position tacks as back pressure affected control of tack motion. Nylon tube which transports tacks to gun had to be flexible, yet sufficiently resistant to abrasion that tacks would not gouge walls. An engineering compromise was reached between large diameter for clearance on turns and small diameter for high driving force. Tack velocity is about 100 fps. Rack rotates tack pot through ratchet coupling.

Interchangeable Hydraulic Drives

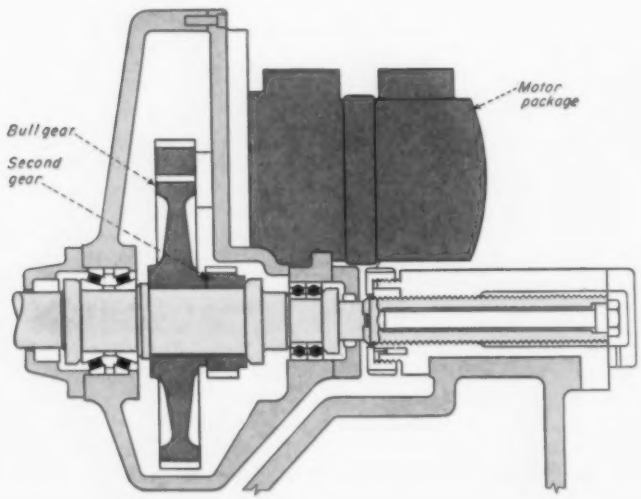
Interchangeable multimotored hydraulic drives are used in a universal tapping and drilling machine developed at the Hanson-Whitney Co., Hartford, Conn., under the direction of Vincent Jamilkowski. Using motors singly or in unison and having four interchangeable drive packages makes available an over-all speed range from 22 to 1600 rpm.



Power package	Speed Range – Rpm			
	Low	Intermed	High	Reverse
1	22–35	—	60	60
2	25–40	40–62	62–100	175
3	100–160	160–250	250–400	400
4	460–640	640–1000	1000–1600	1900



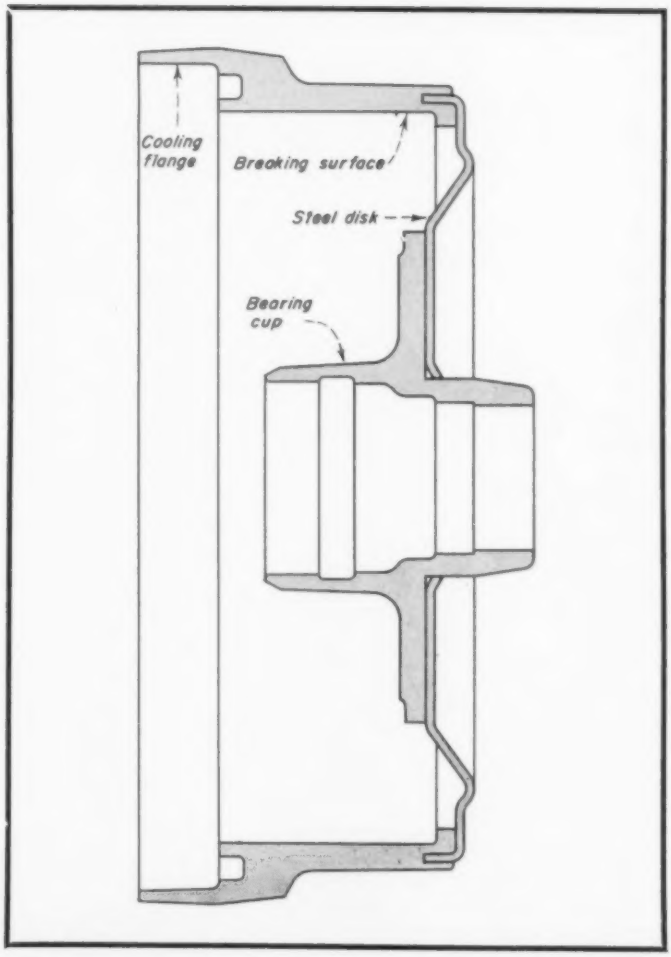
HYDRAULIC DRIVES WERE SELECTED for flexibility in obtaining a wide range of step-less speed changes and ability to reverse spindle rotation quickly. For this application, cost is less and equipment is more compact than for an equivalent electric motor drive with gear transmission for speed changes. Speed ranges are selected with two control valves. Lower valve in diagram selects low forward speed or reverse while upper valve selects intermediate or high forward speeds. Motor MF_1 drives spindle at high speeds and in reverse while motor MF_2 drives spindle at intermediate speeds. For low-speed range, both motors drive in parallel. Either motor idles when not in use. An adjustable pressure switch is used as a simple sensitive interlock which reverses and stops machine if torque at tool becomes excessive.



MOTOR PACKAGE bolts to upper rear section of spindle head where pinions on fluid motors engage bull gear on spindle. Second gear on spindle is for use with packages requiring different gear ratio. All gears are shaved. Lead screws bolt to rear end of spindle and are driven with a tongue and groove; an adjustable collar removes backlash between threads of nut and lead screw. This assembly is easily interchanged and can be replaced by a hydraulic cylinder when machine is used for drilling and reaming. Spindle head rides on linear ball bearing ways.

Wide-Flange Brake Drum

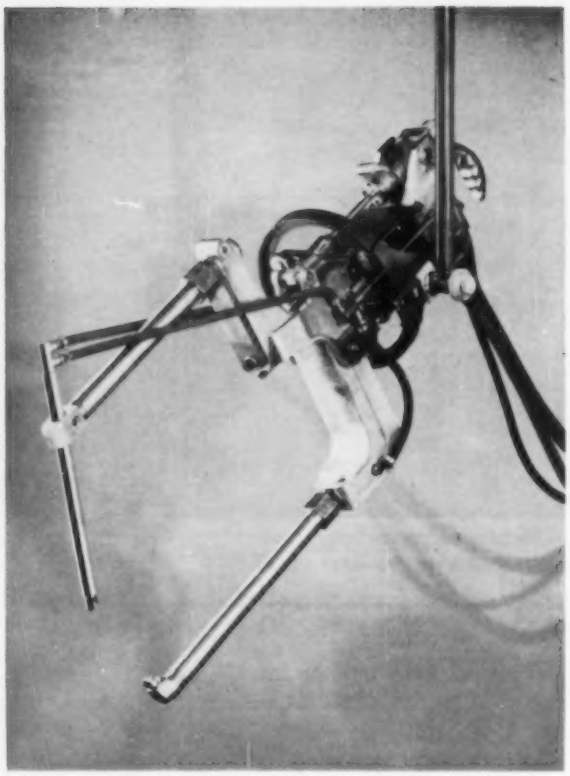
An extra inch of width on the brake drums of the Rambler Rebel, American Motor's high-powered compact car, increases the heat-dissipating ability to reduce "brake fade" during high-speed stops. Higher braking capacity was required to accommodate the performance obtained when a 255 hp V-8 engine was installed in this 3353 lb car.

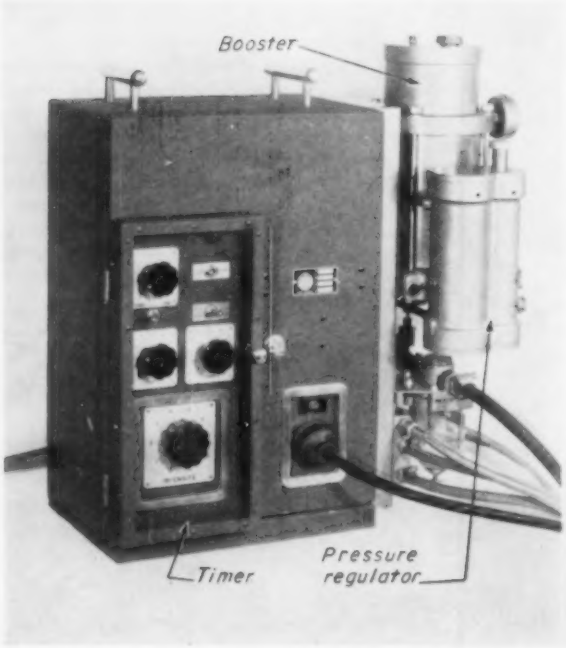


BRAKE DRUM WIDTH is limited by clearance required between drum edge, steering knuckle and tie rod components. Added width is a flange which extends out from the braking surface and provides more metal to absorb and dissipate heat. Drum surface area in contact with brake shoes is the same as in other Rambler cars. Drum is made by pressing cast iron cylinder and bearing retainer cup onto stamped steel disk. Increases in unsprung weight and manufacturing costs are offset by gains in braking action.

Compact Welding Gun

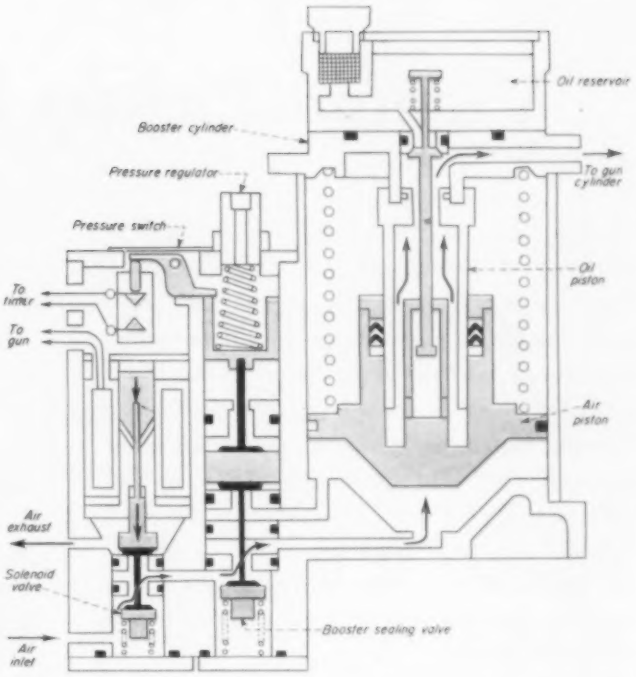
By making a water-cooled transformer an integral part of the gun, ARO Welding Machine Co., Villejuif, France, has developed a light-weight resistance welding equipment which can make up to 3340 spots per hr in 16 ga cold rolled steel. Placing transformer close to electrodes reduces power losses in cables to about one-third the loss encountered when transformer is mounted separately. Hydraulic actuation of electrodes keeps clamping pressure approximately constant throughout the welding cycle. Gun can weld sheets up to 12 ga thickness.

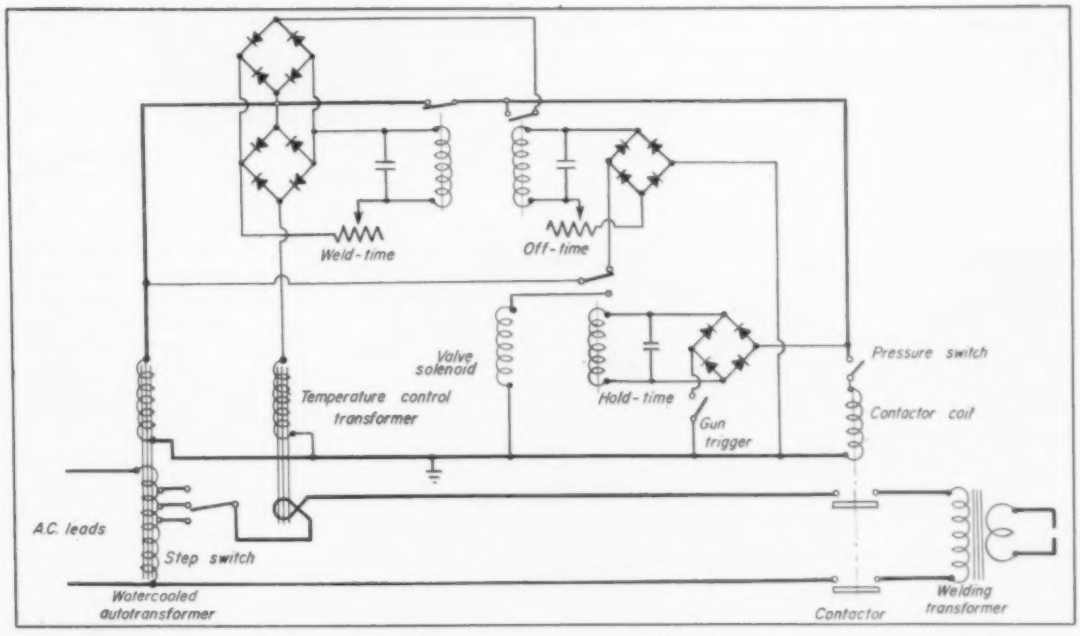




GUN IS MOUNTED in a gyroscopic suspension consisting of a ring and an offset hanging boom. This mounting allows operator to rotate gun about its longitudinal axis as well as about axes in the horizontal and vertical planes. Compactness and light weight are obtained primarily by design of transformer and hydraulic actuating system. Transformer primary is wound in two sections: one section is wound under and one section is wound over the water-cooled secondary winding. Secondary coil is formed of flat strips welded to a central cooling tube. This construction efficiently cools both primary and secondary and enables this small transformer to carry short-circuited secondary currents of 11,000 amps. Hydraulic system utilizes a pneumatic-hydraulic booster to amplify plant air pressure. Pressures of 800 psi are obtained with a hydraulic cylinder one-fifth the size of cylinder required if plant air pressure was applied directly. Electrode carriers and tips are water cooled. Welding currents, welding time, forging time and repetition rate for automatic operation are controlled by an electric timer actuated by a pressure switch.

PNEUMATIC BOOSTER AND PRESSURE REGULATOR act together to prevent start of welding cycle until preset pressure is exerted on work by electrodes. When operator presses gun trigger, solenoid valve in pressure regulator admits air to booster cylinder which forces hydraulic cylinder to clamp electrodes against work. When air pressure reaches preset value, force of spring on regulator piston is overbalanced and air is admitted to entire piston surface. This causes regulator to snap upward and actuate switch which starts welding cycle. Regulator motion also seals booster cylinder, which now acts as an accumulator to maintain pressure at electrodes. When cycle is completed, de-energized solenoid valve exhausts booster cylinder and resets mechanism to initial position. Diagram shows position of components while electrode pressure is building up to preset value.

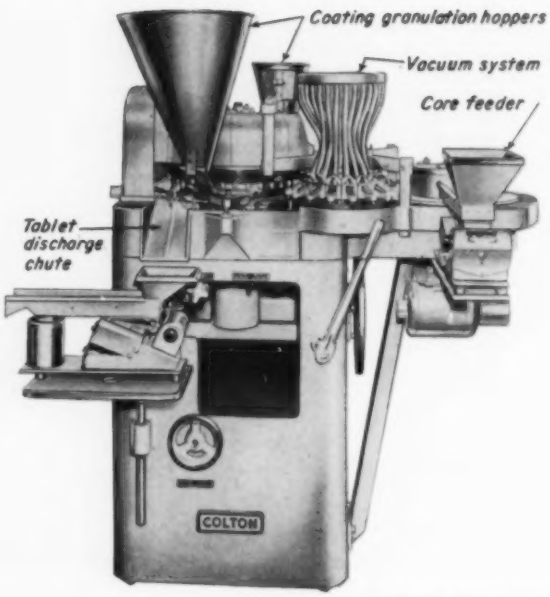


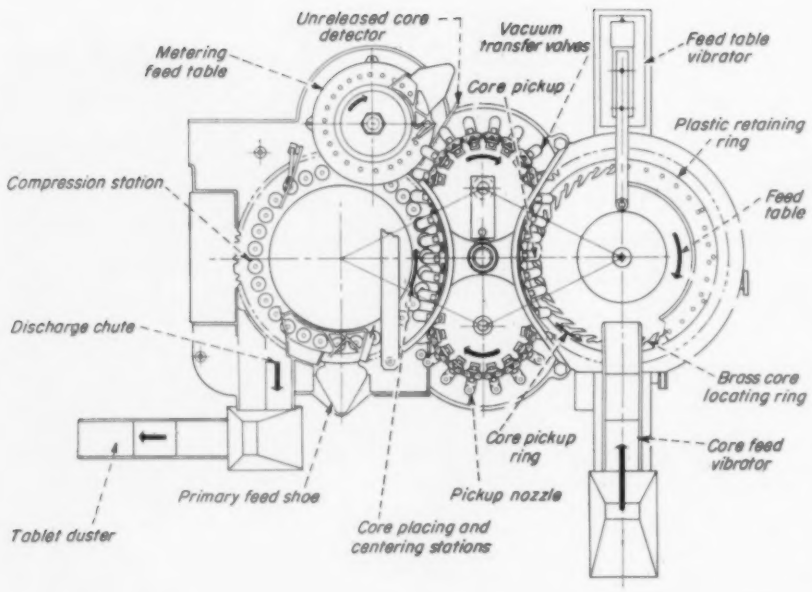


TIMER CIRCUIT controls weld time, forging time, repetition rate and magnitude of welding current. To prevent cold welds, provision is made to vary "weld-time" cycle in inverse proportion to magnitude of electrode current. In typical cycle, gun trigger energizes rectifier and relay of "hold-time" circuit which, in turn, energizes solenoid valve in pressure regulator. When proper electrode pressure is established, pressure switch contact closes and energizes contactor to feed welding current to the electrodes. Welding current passing through primary of temperature control transformer energizes lower rectifier, charges capacitor and energizes relay in "weld-time" circuit. Welding current contactor is de-energized. "Weld-time" relay is now energized by upper rectifier from low-voltage coil of auto-transformer through contact of "off-time" relay. When capacitor in "hold-time" circuit discharges, its relay energizes the "off-time" circuit and de-energizes solenoid in pressure regulator. When "off-time" relay is energized "weld-time" relay is de-energized and unit is ready to start another cycle. A break in the ground lead opens all circuits and renders gun inoperative.

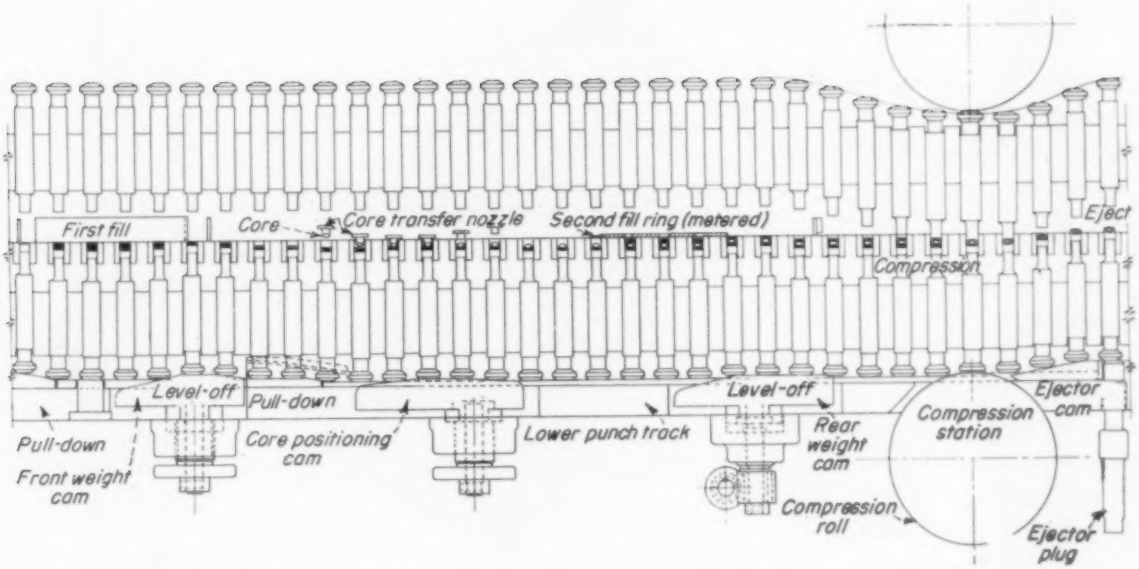
Vacuum Pickup Positions Pills

Carrying tablet cores to moving dies, placing cores accurately in coating granulation, and preventing formation of tablets without cores were basic problems solved by engineers who designed this compression coating machine at the Arthur Colton Company, Detroit, Mich. These problems were solved by using vacuum pickup fingers on a moving chain to transfer cores from a feeding table to dies moving 120 fpm. Replacing one set of pressure rolls on a standard high-speed tablet press with a core-feeding mechanism and adding vacuum transfer system evolved a new machine which dry coats up to 900 tablets per minute.



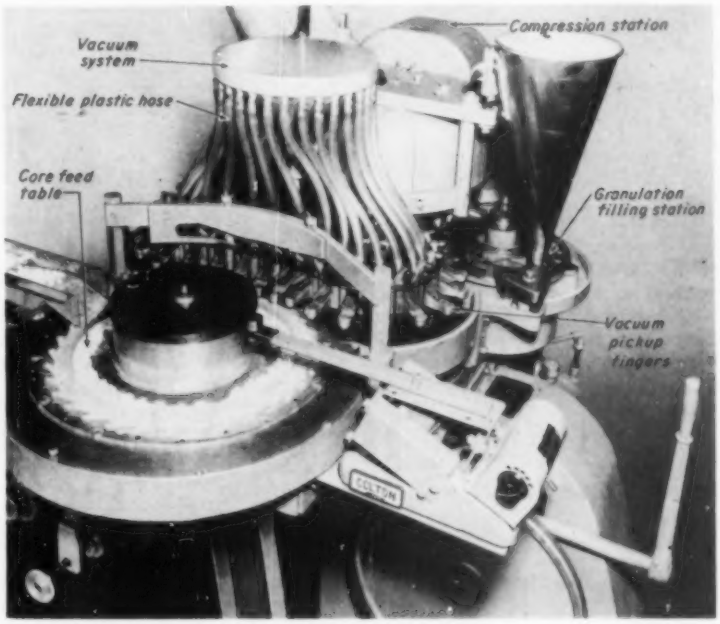


CORES ARE HOPPER FED to a rotating feeder disk through a tablet duster. This disk is vibrated clockwise under a slotted pickup ring which rotates counterclockwise. Each slot in pickup ring holds two cores and lets broken tablets pass through to an area under feeder table. Cores are picked from ring slots, carried to tablet press dies and deposited in dies by vacuum nozzles fastened to a chain driven by press die table. This chain also drives the pickup ring to synchronize motion of ring slots and pickup nozzles. Coating granulation is fed into dies ahead of and after station where vacuum pickup deposits a core in each die. Compressing rolls are at left side of machine. Principal design objectives were to evolve a machine to apply dry coatings at speeds which lowered costs below those of liquid coating techniques and was adapted to positive brand identification.



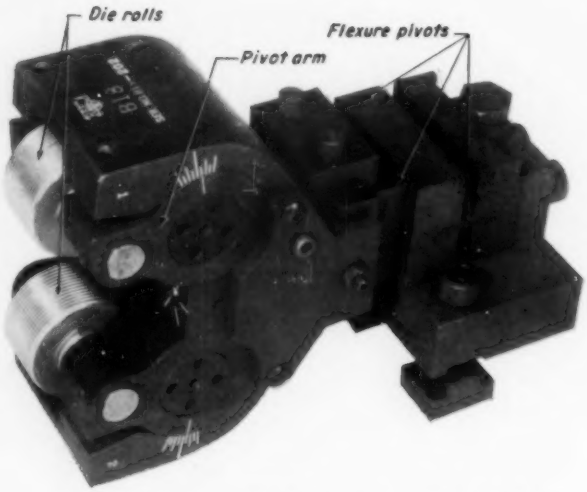
TABLETS ARE PRESS-COATED in four basic steps. A layer of coating material is placed in moving die cavity at first fill station at left. A core is placed in this lower layer and a top layer is placed over core at second fill station. Material assembly is compressed into a tablet as dies pass between compression rolls at right and then is ejected. High die speed required that cores be positioned by positive action of mechanism as a free falling core would move only 1% of required distance in time available. Vacuum method holds cores firmly, but gently, and releases them easily. Pressing cores into lower granulation layer prevents shifting by centrifugal force or machine vibration and using small clearance between transfer fingers and die cavity achieves placement accuracy within 0.005 in. Vacuum system also solves core-less tablet problem. Lower coating layer is sucked from die cavity by transfer finger nozzle if no core is on finger when it is pushed into die. Then, second granulation layer is insufficient material to form a tablet and is ejected uncompressed.

DEVELOPMENT TIME WAS REDUCED by building new machine around basic elements of company's latest high-speed tablet press. One set of compression rolls were removed and replaced by feeder disk table and vacuum transfer mechanism. Using standard tooling allows users to utilize punches and dies already in his plant. To avoid problems which occur if core is not placed in die, a feeler in return path of transfer fingers detects undeposited cores and operates a snap switch to stop machine. Tablet fragments generally are discarded at feeder disk but will be sucked out through pickup nozzle if caught in feeder disk slots. Coated tablets can be up to $\frac{3}{8}$-in. dia. Total standard depth of fill is $\frac{1}{2}$ in. and compression force is 6000 lb. Core shapes can be rounds, ovals or capsules.

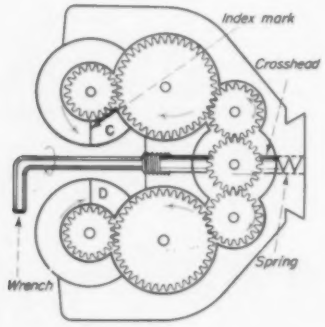


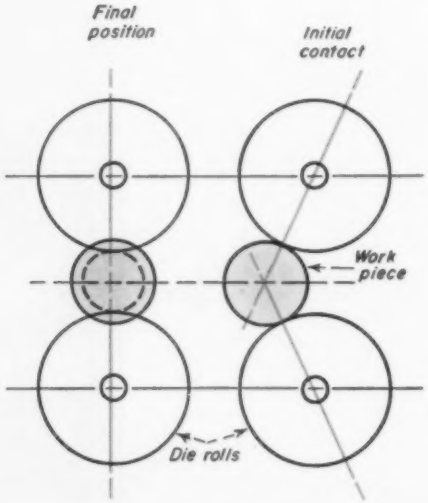
Self-Compensating Thread Rolls

Flexure pivots in the mounting adaptor and a gear train in the die head align and synchronize dies with work in this thread rolling attachment for screw machines and turret lathes. Primary design objective was to make attachment adaptable to a variety of slides and turrets on many makes of machine tools. Flexibility includes range of application as well. With four die heads, up to 460 common screw threads can be rolled on workpiece diameters up to 2¼ in. Made by the Reed Rolled Thread Die Co., Worcester, Mass., this attachment uses cylindrical dies to cold form threads in a single pass. Thread formation is independent of spindle speed.

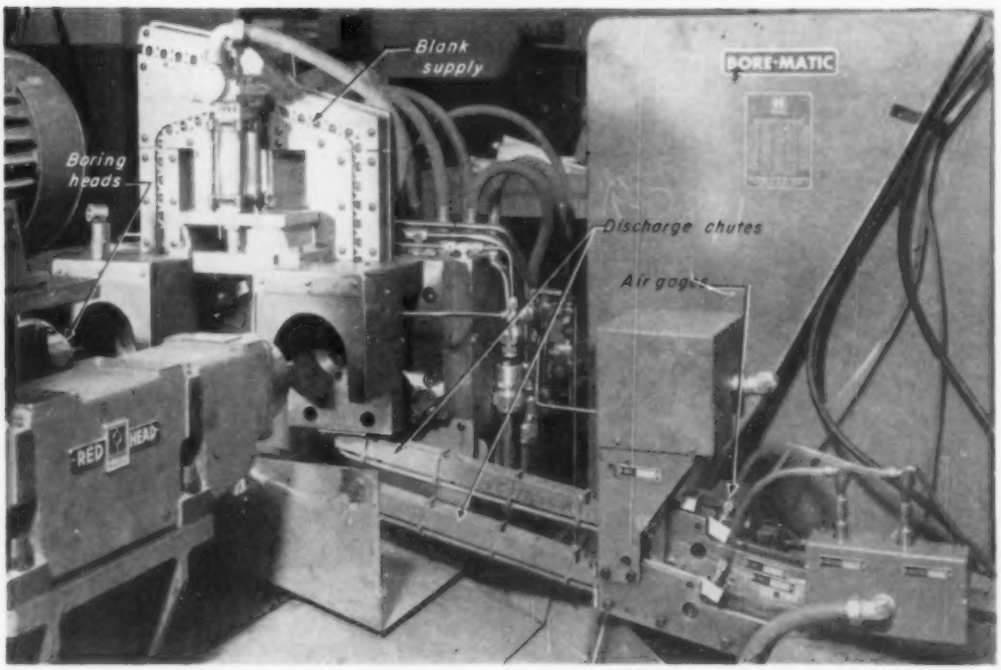


USING TWO DIE ROLLS prevents formation of shallow threads by balancing all forces on workpiece except those in direction of diehead motion. Flexure pivots built into mounting adaptor accommodate axial and lateral misalignment of the diehead. Two reeds are used to keep rolls parallel to work axis when compensating for axial displacements and a single reed lets rolls float vertically to adjust themselves to workpiece before starting threads. Misalignments are in range of 0.030 in. Die rolls are easily changed and adjusted. Spindles which support rolls are held in pivot arms by socket screws and are easily removed. Socket screws are used also to adjust pivot arms for proper clearance between rolls, which is set with a gage. Threads on rolls are matched with another screw adjustment which shifts a crosshead carrying one gear in a train which synchronizes roll rotation. Rolls are matched when index marks on their sides are aligned.



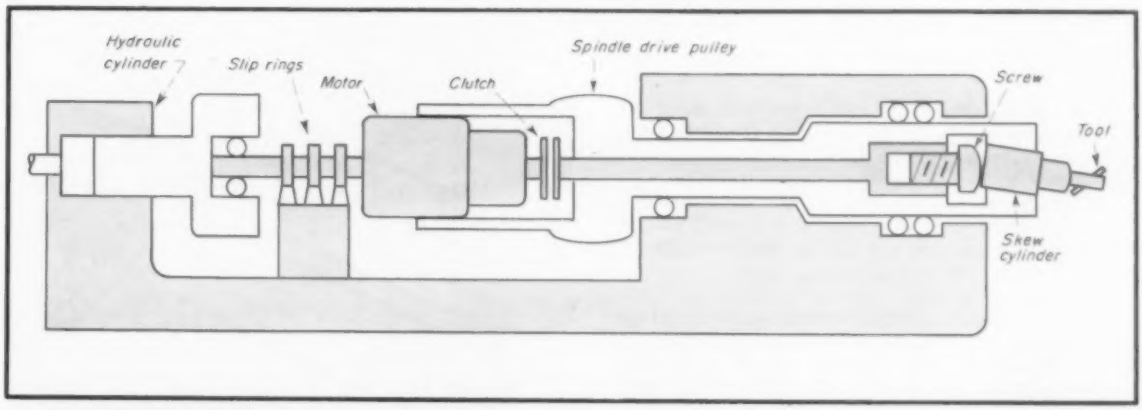


LINES OF CONTACT between rolls and workpiece establish synchronization between rotating threads. These lines remain in planes connecting roll and workpiece axes as threads are formed. To make this possible, a phase shift must occur between rotating rolls and workpiece as die rolls advance. Required change in synchronization is obtained by spring-loading the crosshead which carries central synchronizing gear. This gear shifts its axis horizontally against spring pressure to introduce required phase shift.

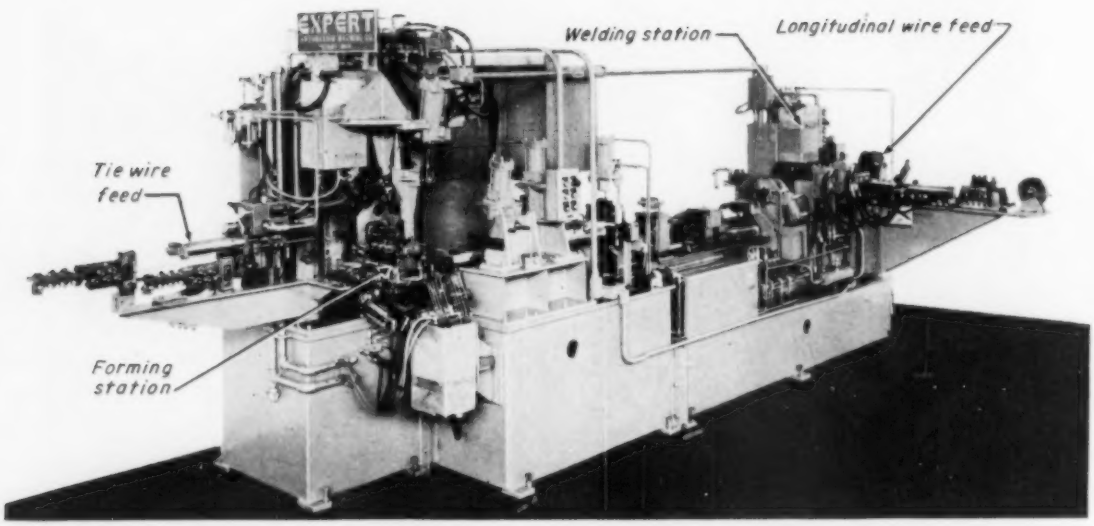


Rotating Tool Reset Automatically

To compensate for tool wear, signals from a parts gaging station in the discharge chute of a boring machine made by the Heald Machine Co., Worcester, Mass., reset the tool while it rotates at high speed. Tool is mounted in a quill positioned by a motor-driven draw rod carried in the hollow spindle. Tool retraction is accomplished by moving draw rod axially with a hydraulic cylinder.



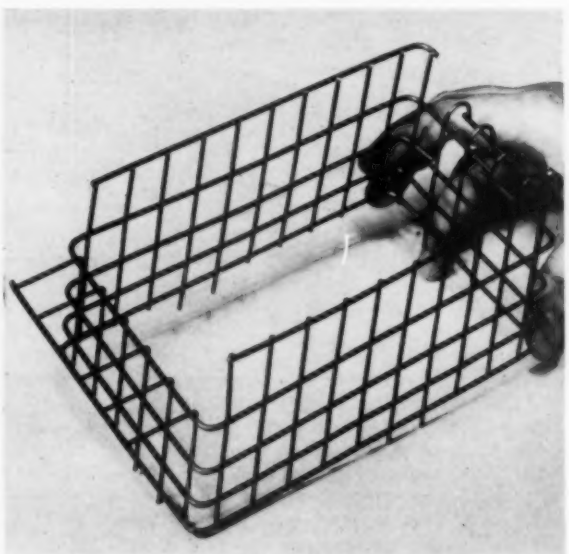
MACHINE FINISH BORES automotive pinion gear blanks with an output of 386 per hr at 75% efficiency. Both faces of the blanks are finished and the bore is semi-finished before parts reach machine. Blank are held stationary and tool rotates continuously. This arrangement avoids down-time penalty encountered when work fixture must be accelerated and decelerated for each machining cycle. When an undersize part enters the air gage, compensating mechanism is jogged so tool takes a slightly deeper cut. Quill which holds tool is connected by a tongue to a short screw. This screw is positioned axially by rotating a nut on the draw rod. Opposite end of draw rod is connected to compensating motor shaft through a clutch which protects motor from overcompensation. Motor selected has to have a balanced symmetrical gear train because it rotates with the spindle. Hydraulic cylinder at rear of spindle retracts tool by pushing motor and draw rod against pressure of springs in spindle nose. Entire head moves on a slide to feed tool into work.



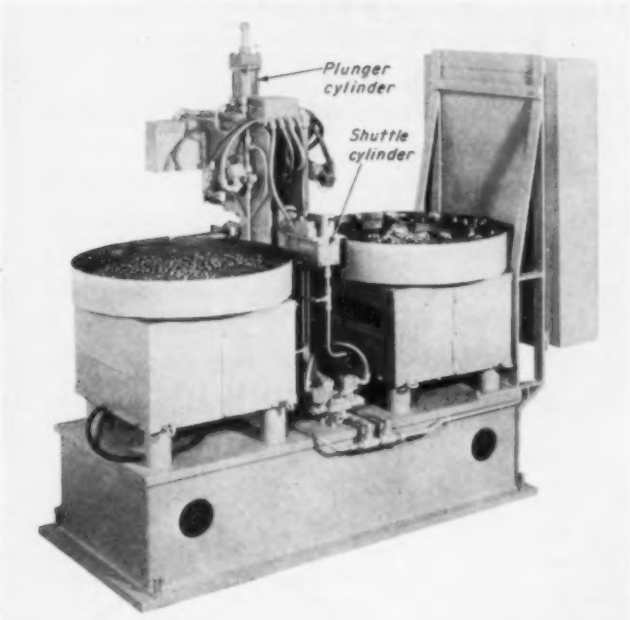
Machine Forms Wire Baskets

Wire racks for automatic dishwashers are made at the rate of 170 units per hr in an automatic welding and forming machine built by the Expert Automation Machine Co., Detroit, Mich. Wire is drawn from bulk reels to form a continual strip of longitudinal and cross-members; wire is cut, formed and welded as it is transferred automatically through the machine. Reserve reels are buttwelded to reels feeding the machine to make operation continuous.

WIRE FOR LONGITUDINAL MEMBERS is fed into right end of machine. These five wires are 0.093-in. dia and are welded to 0.070-in. dia cross wires fed in pairs to a welding station. After welding operation, cross wires are sheared and basket pattern is advanced and indexed for next welding cycle. As pattern feeds through machine it is notched, trimmed and cut for forming operations. Hanger sections are formed first, then pattern is advanced to a fixture which folds it into a basket and makes the final welds. Two longitudinal tie wires are fed in left end of machine, cut to length and welded to the basket after it is formed. Forming fixture consists of two double-jointed folding arms which form four-sided basket with two motions, and hold it in position for six welding guns which simultaneously make final welds. Basket is stripped from machine automatically.



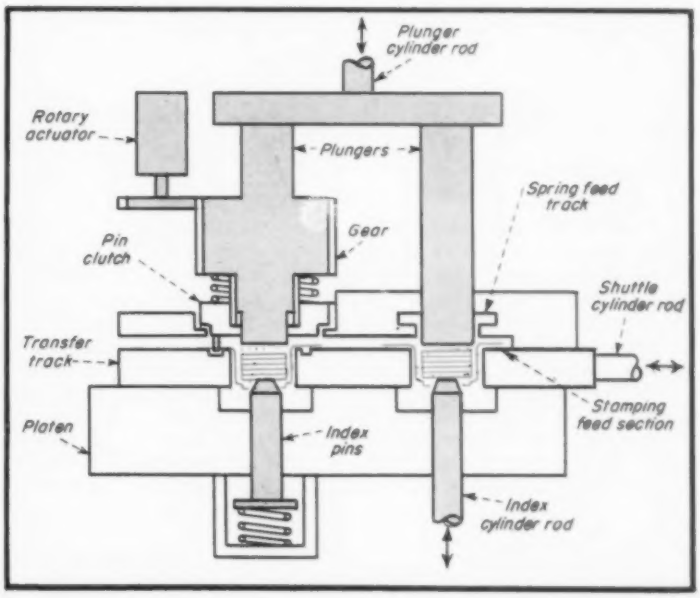
Clutch Assembled Automatically



A close-coiled spring is wound up and assembled in a metal stamping to form a slip clutch at the rate of 1440 units per hour. After assembly, spring is oriented relative to holes in flange. Clutch is component of automotive window regulator. Machine was designed and constructed by the Omer E. Robbins Co., Detroit, Mich.

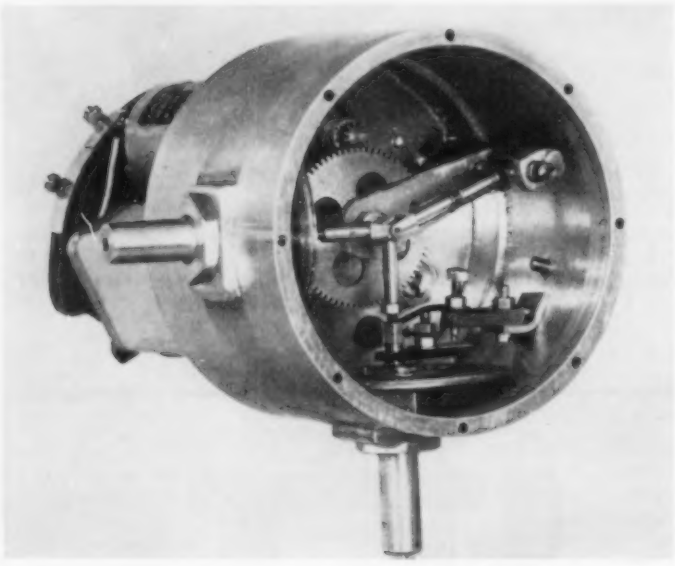
BASIC PROBLEMS were to hopper-feed, assemble, and orient parts for next automatic operation. As clutch housing is a stamping, ample clearance was required to accommodate variations in concentricity between flange OD and housing body. This prevented eccentric parts from cam-locking in feedtracks but required auxiliary centering devices based on concentricity of holes. Also, oversize springs screwed away from housing bottom when rotated for orientation. Designer's approach was to modify machine so out-of-tolerance parts could be assembled successfully. Stampings and springs are fed into machine by air jets along horizontal tracks. Feeding with jets, instead of by gravity, simplified track design.

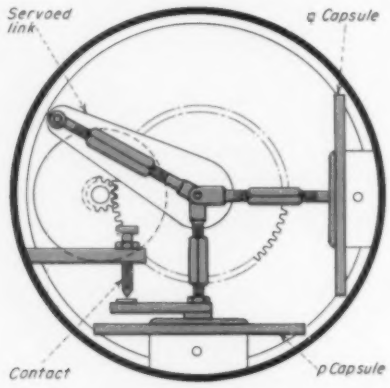
ASSEMBLY MECHANISM consists of two plungers, a shuttle, and associated indexing parts, and is operated with compressed air. Parts feed into shuttle at right-hand station from opposite sides of machine and at different levels. Index pins mounted beneath the shuttle center housings in each station. Right-hand plunger pushes compressed spring into housing. Left-hand plunger holds spring in position as pin clutch rotates housing. Clutch first turns ½ revolution to engage holes in flange, then one full revolution to establish orientation.



Aircraft Stall Warning

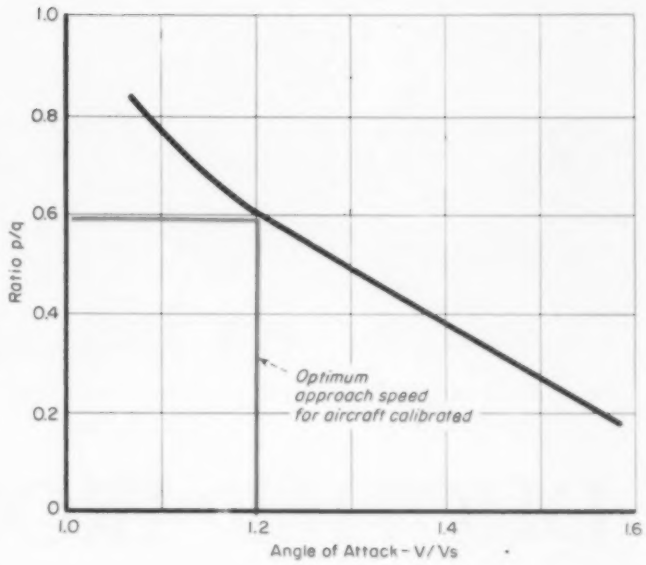
Two devices recently developed in England help pilots maintain an optimum flight attitude when landing and warn of approaching stalls during low-speed maneuvers. One instrument, a mechanical computer, composes vectors representing pressures at two points on the airfoil section and derives an indication of the aircraft's angle of attack from their ratio. Developed by R. T. Youngman, an aeronautical consulting engineer, this instrument also aids pilots in maintaining correct angles of attack for long-range performance. The second device is a snap-action switch developed by Kelvin & Hughes Ltd., which is actuated by motion of a vane or tab. This switch energizes a visual or audible alarm signal intermittently during the transition from laminar to turbulent flow at a selected airfoil station and warns the pilot as he approaches an unstable attitude.

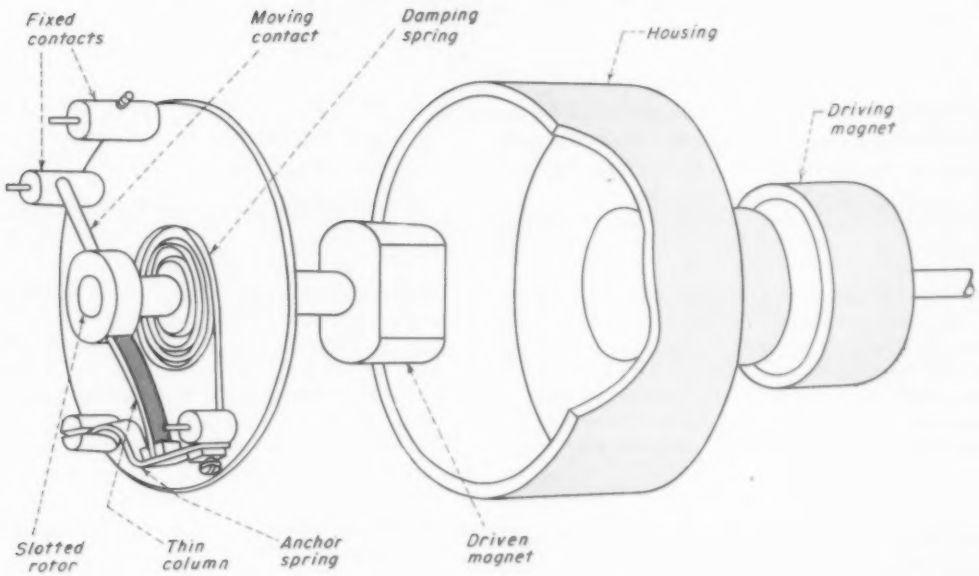




COMPUTER DETERMINES RATIO OF PRESSURES by positioning a link which supplies reaction to forces exerted by pressure capsules. When linkage system is in equilibrium, capsule links are perpendicular and servoed link is coincident with resultant of capsule force vectors. Angular position of servoed link θ is used to calibrate the cockpit presentation as $\tan \theta = p/q$, where p and q are the capsule pressures tapped from points on the airfoil section. Pressure q is the stagnation pressure. Computer is sensitive to pressure variations equivalent to 0.25 knots air speed change. High sensitivity is made possible by force-balance principle in which capsules are not deflected at equilibrium position and by causing the servo to hunt through its null. Relay which actuates servo drive is energized by a single contact which makes or breaks as the computing linkage changes position. By using cross-connected normally-open and normally-closed contacts, relay reverses servo motor each time it is energized or de-energized. This causes computer to hunt through equilibrium position and gives instantaneous response to small pressure changes by avoiding a dead zone. Mechanism is designed to fit in a standard 3-in. aircraft instrument case. Adjustable markers on the instrument dial can indicate optimum angles of attack for climb, cruise and landing.

COMPUTER OUTPUT is useful indication of angle of attack because ratio of pressure at a selected airfoil station to stagnation pressure remains substantially constant at all air speeds for any given angle of attack. This ratio varies almost linearly with angle of attack as represented by dimensionless ratio V/V_s, where V is airspeed and V_s is the stalling speed. With an angle of attack display available, speed adjustment for optimum flight attitude when cruising can be continuous without reference to gross-weight calculations. Also, naval aircraft making deck landings can reduce safety margins over stalling speeds and approach at the optimum speed for the particular aircraft.





SWITCH DEVELOPED BY KELVIN & HUGHES is intended to serve as a stall alarm on slow flying aircraft such as used for crop dusting or traffic control. It is mounted under the wing skin and is connected to a vane or tab which responds to air flow. Vane motion drives switch contact-rotor through a magnetic coupling. Snap action with low driving torque is obtained by causing a strut connected to the rotor to fail as a thin column. One end of strut is attached to a leaf spring anchor while other end rides in radial slot in contact rotor. Anchor spring is adjusted at assembly so distance to bottom of rotor slot is less than strut length when rotor passes through dead-center position. This places load on strut which exceeds critical value indicated by Euler's equation and causes the strut to buckle. Sudden deflection of strut, when failure occurs, snaps contact against its terminal. Snap action occurs when making contact in either direction, but breaking action is not positive. Switch has moderately fast repetition rates and is rated at 500,000 switching cycles while carrying a 1 amp current. Magnetic coupling is used so switch can be hermetically sealed and to avoid friction of shaft seals.

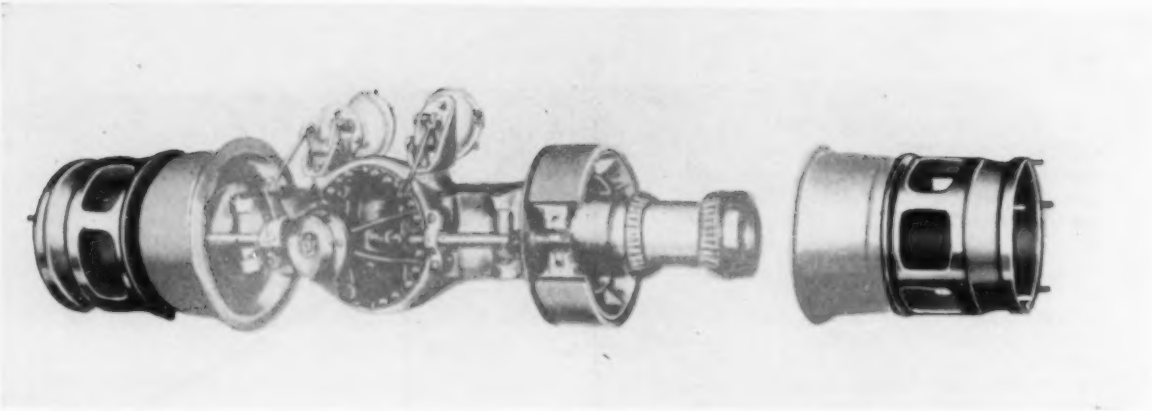


Fig. 1—Euclid rear-axle assembly with new ductile cast-iron wheel. Brake drum is bolted to wheel.

DUCTILE IRON WHEEL HALVES COST

Change to a new material and redesign to exploit its casting characteristics reduced cost with no loss in strength for wheels of mining and earth-moving off-the-road vehicles.

H. A. PELLER, *Chief Design Engineer, Development*
R. A. SEIPLE, *Chief Process Engineer*
F. L. MAIN, *Supervisor of Experimental Testing*
Euclid Division, General Motors Corp.

Low-cost ductile-iron rear wheels, Fig. 1, now standard equipment on Euclid heavy-duty off-the-road dump trucks, represent a saving of 47% over a previous design based on a steel casting. Wheels still last as long as the trucks, which are designed for the service encountered in large-scale mining, construction and excavating operations under all conditions of weather and terrain.

Evolution of a Wheel

After starting out as a steel casting, Fig. 2, the wheel was redesigned to a fabricated structure and went through the succession of cost-saving redesigns shown in Fig. 3. These fabricated wheels consisted of three or four steel outer rings welded to a steel hub. The hub itself was first cast-weld, then forged and welded to a stamped flange, later cast and welded to a stamped flange, and finally designed as an integral steel casting. As a result of these redesigns, production costs were reduced by 11%; but it became evident that additional improvement would involve the use of a new material.

Investigation showed that ductile iron held the best promise. It permitted a 10% reduction in weight for a given volume of metal, it had high strength, good elongation, a high degree of machinability, and it could be cast easily and to close tolerances. These properties were exploited in a new design, Fig. 4, which used longitudinal spokes for a more open structure in the central section. This change in design, made possible by the high fluidity of the new material, helped to lower weight and cost of the final ductile-iron casting, while making the wheel more accessible for cleaning and maintenance.

Extensive testing of the new wheel, both in laboratory and in field, proved that the mechanical properties of nodular iron could be held within close limits on regular production runs, resulting in a uniformly sound and dependable wheel.

Where Savings Came From

Cost of the ductile-iron wheel is 40% less than for the fabricated wheel and 47% less than for the original cast-steel wheel. These savings are:

1. An approximate 10% reduction in weight because of lower specific gravity.
2. Additional reduction in weight from new open casting design.
3. Reduction in the number of pieces, reducing handling time.
4. Close casting tolerances minimize the amount of metal removed in machining.
5. Cutting the number of machining and finishing

Fig. 2—The wheel was originally this steel casting. ▶

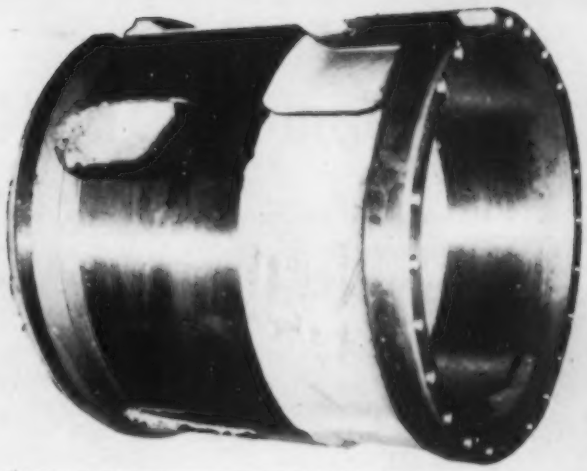


Fig. 3—Four successive redesigns of the fabricated steel wheel reduced cost, but not enough.

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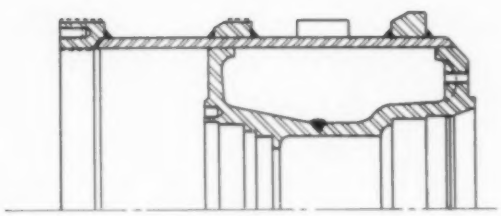
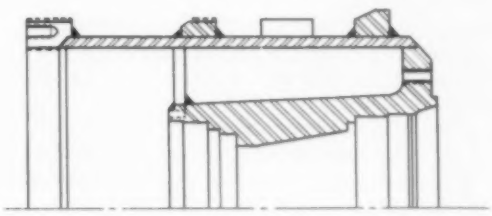
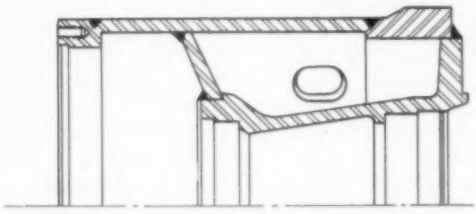


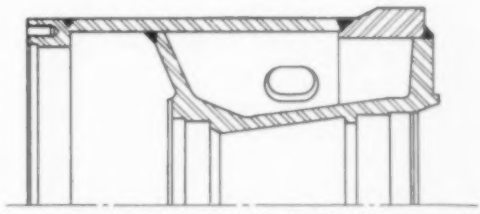
Cast-welded hub and four rolled outer rings



Forged hub, stamped flange and four rolled outer rings

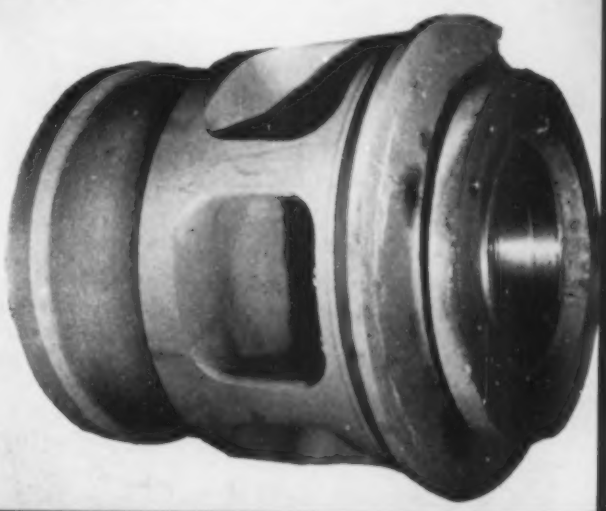


Cast hub, stamped flange and three rolled outer rings



Cast hub and three rolled outer rings

Fig. 4—This cast ductile-iron wheel costs just a little more than half as much as the original cast-steel wheel and is easier to keep clean. ▶



operations from 20 for the fabricated steel wheel to 5 for the cast ductile-iron wheel.

The success of ductile-iron wheels for dump trucks has brought about a review of wheel production for other vehicles. Euclid's new scraper line is now being fitted for ductile-iron wheels. Savings on this line are expected to equal those already achieved on the dump trucks, while maintenance, too, will be easier.

How to DESIGN *with* SHIMS

Relationship between shim thickness, clearance and tolerance requirements; recommended shim sizes; design of inspection fixtures to determine correct shim size at assembly.

THOMAS BARISH
Consulting Engineer
Cleveland, Ohio

Shims offer a quick and low-cost method for attaining accurate fits and adjustments in assemblies of precision parts, particularly in:

1. Very small assemblies in which units such as gears would be injured by careless adjustment of a take-up nut. Often there may also be insufficient room for a nut and locking device.

2. Very large units such as turbines, where adjusting nuts are impractical.

3. Adjustments that are needed only at initial assembly and must remain fixed throughout operation.

In each of these applications shims can be replaced by threading one member and using an adjusting nut; but threads are difficult to keep square, are costly and may require field resetting. Shimming may also be costly if repeated assembly is necessary to determine proper shim size, but this process can be simplified by proper tooling.

Tolerance Requirements

Where clearance or endplay in the final assembly is required, the amount should be as large as possible; endplay between 0.001 and 0.002 in. may be twice as expensive to assemble as 0.001 to 0.003 in. Clearances under 0.001 in. are usually impractical to hold with shims.

The amount of space to be filled by shims is seldom critical and has little effect on cost or care in handling. Hence, wider tolerances may be used on mating parts with consequent reduction in manufacturing cost.

For example, the shaft and housing assembly, Fig. 1, consisting of a shouldered shaft, two bearings, two end covers and a housing, are to be assembled with a specified endplay. Specified tolerances are:

	Usual tolerances	Suggested tolerances when using shims
Shaft shoulder length, (A)	−0.002 in.	−0.003 in.
Bearing width, (B)	−0.005 (x2)	−0.005 (x2)
End cover offset, (C)	−0.002 (x2)	−0.003 (x2)
Housing length, (D)	+0.003	+0.005
Total tolerance	0.019	0.024

As will be seen, the increase in tolerance from 0.019 to 0.025 can be compensated by stocking only three additional shim sizes, thus permitting the broadening of all but one of the tolerances by 50% or more.

End Play vs Shim Thickness

Shim space can be filled with one, two or at most three shims, no matter how broad the sum of tolerances by stocking a large selection of shim thicknesses.

Minimum thickness for a shim is 0.006 in., preferably not under 0.008 in. Thinner shims are easily wrinkled, awkward and sharp edged for handling. They slide out of place more easily, and too many are required to build up the needed thickness. The way to avoid thinner shims is to shift the nominal dimensions of a design so that the minimum clearance is greater than the recommended 0.006 or 0.008 in.

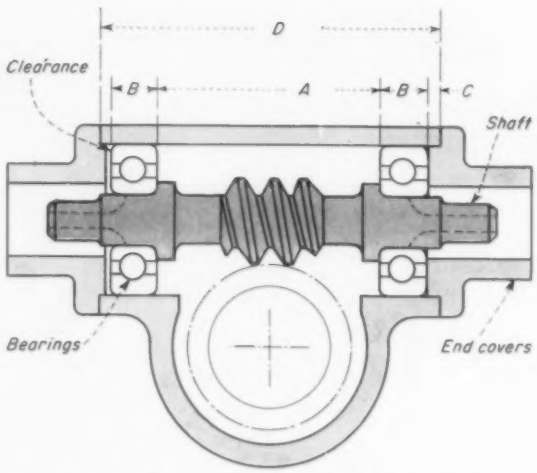


Fig. 1—Typical bearing assembly designed so that clearance between left end cover and bearing will be filled by shims to give correct endplay specifications.

When production is over 1000 units it is best to buy a full series of shim sizes in increments equal to the maximum allowable endplay variations. If the endplay may vary between 0.001 and 0.003 in., shims should be purchased in increasing increments of 0.002 in. Then only one shim is needed for each unit.

The number of different sizes, however, need not be excessive. In Fig. 1, with an endplay specification of 0.001 to 0.003 in., 13 sizes of shims would be required: 0.008, 0.010, 0.012 . . . 0.032 in. The total shim variation is 0.024 in. (0.032−0.008) to cover the required 0.024 in. tolerance range suggested above.

An assembler need only pick out one sturdy shim and, if supplied with an assembly fixture, does not have to do any computations. The saving in rejects can be considerable. The common practice of using 0.003, 0.005 and 0.010 in. thickness shims for all spaces usually requires inserting three to six shims per unit. The suggested method requires only one per unit with possibly 50% of the shims not used because of the distribution of tolerances.

If the 13 shim sizes above is considered excessive,

TABLE I—SHIM SIZE DISTRIBUTION

% In Each Size	Number of Sizes									
	5	6	7	8	9	10	11	12	13	14
1st size	10	10	10	5	5	5	5	5	5	5
2nd size	25	25	15	10	10	5	5	5	5	5
3rd size	60	40	20	15	15	10	10	5	5	5
4th size	25	40	50	40	20	15	15	10	5	5
5th size	10	25	20	40	50	40	20	15	10	10
6th size		10	15	15	20	40	50	40	20	15
7th size			10	10	15	15	20	40	55	40
8th size				5	10	10	15	15	20	40
9th size					5	5	10	10	10	15
10th size						5	5	5	5	10
11th size							5	5	5	5
12th size								5	5	5
13th size									5	5
14th size										5
Total %	130	130	140	140	150	150	150	160	160	170

to stock, particularly for shorter runs, a very effective compromise calls for not more than two shims per unit and reduces the number to five:

Opening in thousandths	Use Shim Sizes
8	8
10	10
12	12
14	14
16	16
18	8 and 10
20	10 and 10
22	10 and 12
24	12 and 12
26	12 and 14
28	14 and 14
30	14 and 16
32	16 and 16

This system is applicable even for runs as short as 100 units. Most of the savings in assembly time and shim costs remain because the average is 1.5 shims per unit versus 3.5 using thin sizes.

Carrying this process one step further and setting a maximum of three shims per unit:

Opening in thousandths	Use Shim Sizes
6	6
8	8
10	10
12	6 and 6
14	6 and 8
16	8 and 8
18	8 and 10
20	10 and 10
22	6 and 8 and 8
24	8 and 8 and 8
26	8 and 8 and 10
28	8 and 10 and 10
30	10 and 10 and 10

Minimum size was changed to 0.006 in. because an opening of 0.014 cannot be obtained with only three shim sizes of 8, 10 and 12.

Purchase Quantities

The number of shims to be acquired in each size may be estimated from a statistical distribution. Percentages in Table I are based on average distribution curves and are only approximate. Note that the distribution changes when more sizes are involved. For example, for the 13 different sizes of shims discussed above, purchase as follows: 5% in sizes 0.008, 0.010, 0.012, 0.014; 10% in sizes 0.016; 20% in size 0.018, 55% in size 0.020; 20% in size 0.022; etc.

These figures include 30% to 70% excess for expected variations. First or second purchase may be based on these recommended percentages; a check at the assembly bench should be made to determine later quantities.

Large production runs will have a sharper peak in the distribution and frequently a bias toward smaller or larger sizes. Also, above nine sizes, the extreme shims thicknesses practically disappear. Most statistical tables assume that all cases fall within the first distribution obtained but in practice there are always individual parts beyond the tolerance specifications that have somehow passed inspection and the above table allows for the use of these parts.

Fixtures

To avoid trial assembly in determining the required shim thickness, a very simple fixture can usually be designed to determine the actual clearance before

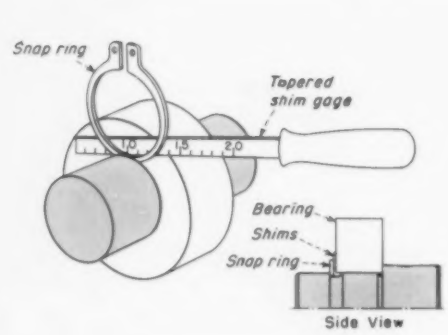


Fig. 2—Simplest method of determining shim size is with a tapered shim gage with graduated thicknesses. It is inserted between the bearing and the shaft shoulder, with the snap ring inserted as shown.

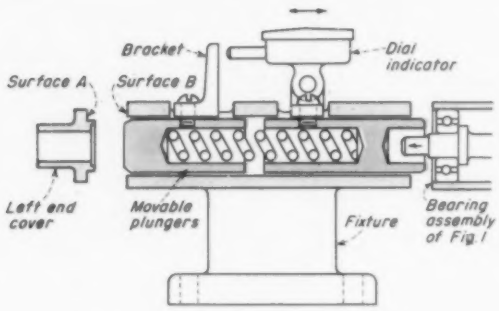


Fig. 3—Fixture for determining clearance in bearing unit of Fig. 1. Dial indicator is shifted to the left by pressing on the bearing assembly; bracket is shifted to the right by the end cover.

assembly. A depth gage or indicator setup is not satisfactory because these methods do not supply the desirable preload to hold the parts together. Further, depth gages are operated off-center, tending to tilt when measuring.

Typical measuring fixtures are illustrated for three assemblies. Fig. 2 shows the use of a tapered shim gage to read the clearance between an external snap ring and a collar or a ball bearing inner race. The snap ring may be held in the groove by hand while the tapered shim gage is inserted to read the desired shim thickness.

A fixture for gaging the ball bearing assembly of Fig. 1 is shown in Fig. 3. The bearing assembly, without the left end cover, is inserted from the right until the bearing housing shoulders against the fixture housing. This moves the dial indicator to the left a certain amount. The end cover is inserted from the left until surface A shoulders against surface B. This moves the bracket to the right. The dial indicator can be calibrated to give the actual clearance. The left part of this fixture could have been omitted if the end cap did not have a centering lip.

A more difficult gaging situation is presented in Fig. 4 where shims are used behind internal snap rings. Before assembling the snap ring and required shim into the bearing assembly, the inspection fixture is used to measure distance x between bearing and snap groove faces. Position of the leaf springs shifts the indicator toward the bracket, similar to the fixture in Fig. 3.

These designs are for small assemblies where it is best to fasten the fixture to a table and move the assemblies to the fixture. Fixtures for larger assemblies can be made portable to move around the asembly room as needed.

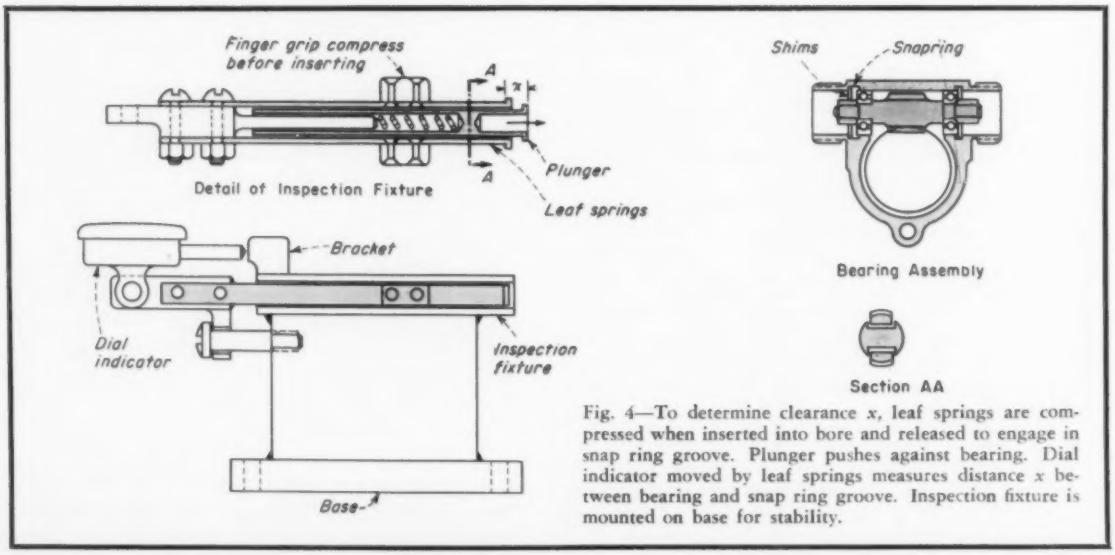
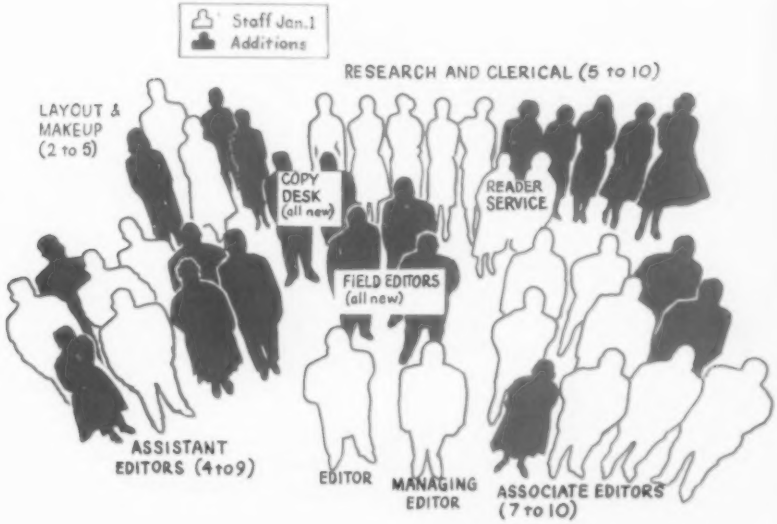


Fig. 4—To determine clearance x, leaf springs are compressed when inserted into bore and released to engage in snap ring groove. Plunger pushes against bearing. Dial indicator moved by leaf springs measures distance x between bearing and snap ring groove. Inspection fixture is mounted on base for stability.

Product Engineering's staff looks up...

Twenty-one new members — 13 of them editors — have swelled our full-time editorial staff to 43 people. They will bring you Product Engineering every week beginning Sept. 9. Foreshortened as the staff may appear here, it has been almost doubled, in this most-recent expansion, to extend its product-planning service to you . . .



Grouped on a terrace of our New York headquarters, with the roof parking area of the Port Authority Bus Terminal behind them, are these groups of the editorial staff . . .

FOR MORE INFORMATION, TURN THE PAGE

Beginning September 9, Product

A 3-in-1 service for you.....

DESIGN EDITIONS . . .

fortnightly beginning Sept. 16, will each have about half the number of pages of the present magazine, with the familiar 4-color covers — an easy-to-handle-and-read presentation of the detailed design data you have found so valuable for 26 years. All the familiar features will be continued, and popular departments amplified.

R & D EDITIONS . . .

published alternate weeks, beginning Sept. 9, will have distinctive 2-color covers, will be bound to open flat. They will contain product-planning and similar data, in compact, quick-reading form, a high-spot summary of what's happening, and what's ahead.

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the big annual compilation of design data from Product Engineering and other sources, will be sent to each subscriber in Mid-October. Here again, improvements are being made to increase its demonstrated reference value to you.

Engineering will be Published Weekly . . .

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The big monthly edition of Product Engineering will, beginning in September, be split into two issues, one published Sept. 16, the other Sept. 30. There will be additional pages of your preferred editorial content, with the technical design information in its present detail, completeness and authority. BUT . . . the news and new products, as well as other departments, will be concerned with events of the preceding week, so you'll be learning what's new more quickly. Each copy will be about half its present size, hence easier to read and handle.

In addition, each alternate week, beginning Sept. 9, you will receive a new edition of Product Engineering, called the Research & Development Edition, completely different in concept, content and appearance. News, interpretation and analysis of significant happenings that affect research, design, development and product planning will be included. There'll also be the latest reports on styling, personnel, and engineering administration. Articles will be short, fast-reading, of broad engineering interest. This is information you've had to seek out in many publications, including new data not heretofore readily available.

You will also receive, each Mid-October, the annual Design Digest issue, a big yearbook of pertinent engineering data that has been found invaluable through the years.

Our staff will be increased more than 50%, including editors located in strategic areas. Ten full-time editors are being added, plus other personnel, and our working quarters doubled to handle additional personnel as they become necessary. Also included will be weekly reports from the McGraw-Hill World News bureaus overseas.

- **a unique, useful, *exclusive* service in your product planning**
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why the change?

Here's why We're Making These Changes...

YOUR JOB IS GETTING BIGGER . . . BROADER

The pace of development is unbelievably fast – and accelerating. New materials, new processes, closer tolerances, better finishes, automatic control and operation . . . all these and more combine to make design engineering more complex.

Modern marketing methods are forcing more frequent redesign and restyling . . . 50 to 90% of industry's income is from designs new or improved since 1950; by 1960, 10% of manufacturers' income will come from products *not yet developed*.

More men must be kept informed faster of design advances, because more men participate in them . . . design is no longer the empirical work of an individual, but the coordinated scientific program of many specialists.

The rise of automatic production requires close coordination of design and production. Costs, sales, patents, research, styling, commercial apects – all these are also involved. Thus the designer must know more about other phases of the business, and other departments must know more about design.

Current shortages of engineering talent make it essential for the engineer to better understand personnel problems and their solutions. Only in this way can he develop men, keep them, and maintain an efficient staff.

YOU NEED MORE ENGINEERING INFORMATION . . . FASTER

You must coordinate broad and specific developments, general principles and precise data, handbook information and latest advances. You must combine an awareness of the new with a knowledge of the accepted. These are now not available from one source – you must filter a sea of paper to get them.

By 1960, industry will be spending more than $9.3 billion annually on research and development – an increase of 150% since 1953.

This is the Age of Alloys, the Age of Synthetics, the Age of Mechanics, the Age of Power, or the Atomic Age, depending upon your informant. Actually, all of these "ages" are part and parcel of the greatest age in the history of the world – the Age of Engineering, in which the design engineer is paramount.

TWO FURTHER SUGGESTIONS . . .

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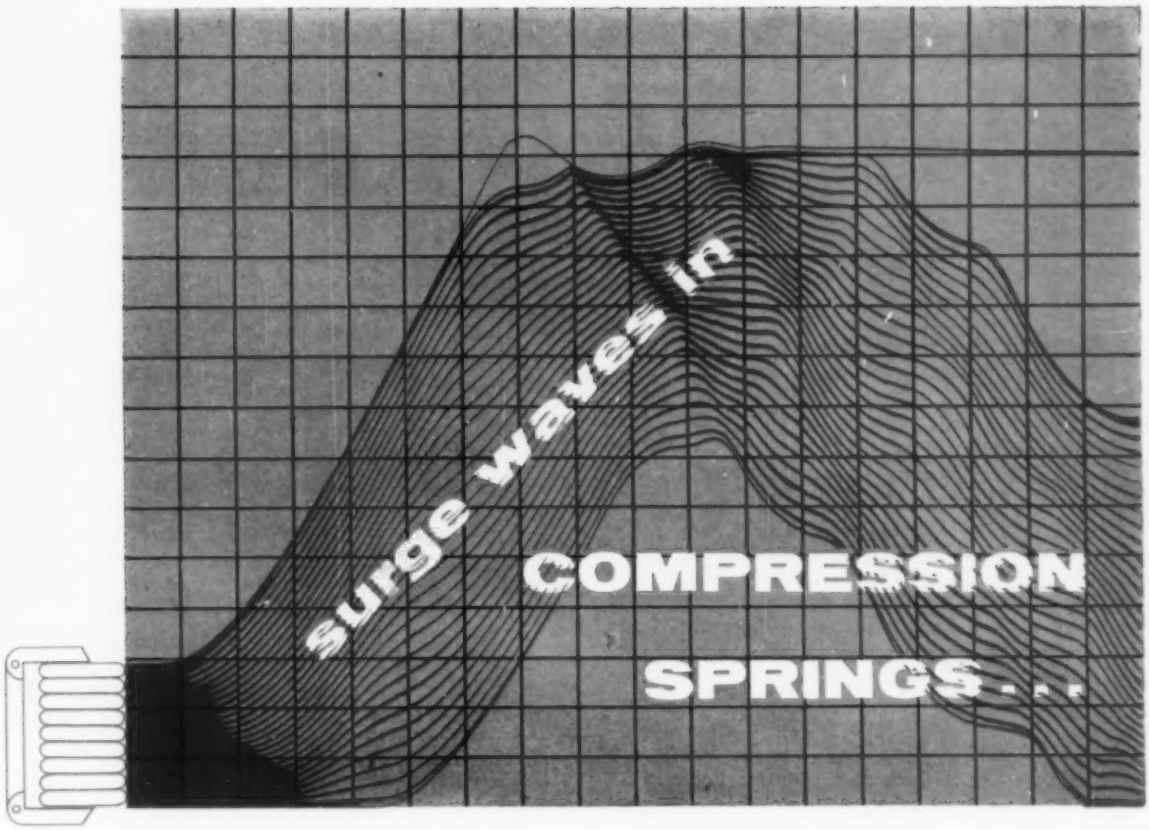
2. We will sincerely appreciate your advice and suggestions, for constantly improving our service to you. Our studies over the past two years have indicated you want this service, but with your help we can make it even more valuable. Watch for the new issues, beginning Sept. 9 . . .

. . . THE EDITORS



DR. KARL MAIER
Manager, Analytical Research Dept.
Winchester-Western Div., Olin-Mathieson Chemical Corp.

. . . ANALYSIS ANSWERS THESE QUESTIONS:

● ***HOW FAST DO SPRINGS EXPAND WHEN DRIVING A MASS OR WHEN RELEASED ALONE? PRESENT THEORIES GIVE INACCURATE RESULTS.***

● ***WHAT IS THE MAXIMUM VELOCITY THAT A SPRING CAN ATTAIN UNDER ITS OWN POWER? THE SURGE-WAVE THEORY PREDICTS A 'VELOCITY BARRIER' THAT A SPRING CANNOT EXCEED NO MATTER WHAT ITS SIZE.***

● ***HOW LONG DOES IT TAKE FOR A COMPRESSED SPRING TO FLY OFF ITS BASE WHEN RELEASED—AND HOW LONG DOES IT REMAIN IN CONTACT UPON IMPACT?***

● ***HOW CORRECT ARE MOST VIBRATION THEORIES? TIME-DISPLACEMENT PHOTOGRAPHS SHOW THAT SPRINGS SUDDENLY RELEASED OR RECEIVING A SHOCK DO NOT VIBRATE SINUSOIDALLY. THEIR MOVEMENTS, IN FACT, CONSTITUTE A NEW TYPE OF FREE VIBRATIONS.***

SURGE-WAVE THEORY

Spring design equations have been based on the assumption that a load applied to the front end of the spring is transmitted through the coils instantaneously. In actuality, the force is transmitted in the form of a shock wave along the axis of the spring wire similar to a sound wave.

This "surge wave" requires a specific time to travel from one end of the spring to another. Velocity of the wave is constant for any particular spring and is not influenced by the magnitude of the load nor, where a spring is struck by a moving mass, the velocity of the mass. However, the impact velocity does affect the amplitude of the wave, resulting in a momentary coil deflection higher than predicted by static design equations.

Design equations developed from the theory of surge waves in springs can quickly answer any of the above questions. Fundamentals of the theory were first published in 1955 (see Editor's Note) and have already found application in landing mechanisms, recoil mechanisms, shock absorbers, automotive valves and cam followers. The theory is not only applicable to springs but can be modified to analyze impact of elastic bodies. With elastic bodies, the surge-wave theory permits a more accurate and quicker estimation of contact time, rebound velocities and inpact stresses. Main points of the theory are summarized below.

How Fast Do Springs Expand?

There are several theories in wide use today to describe the motion of a spring, Fig. 1, which imparts a velocity to a mass M by preloading the spring and suddenly releasing a sear or latch. The spring is defined by its parameters, such as wire diameter, mean diameter, and number of coils, which also determine its active mass m. To satisfy the boundary conditions at the front end A, the accelerating force on M must equal the force transmitted from the front end to the mass, resulting in a differential equation of spring motion

$$M\frac{d^2y}{dt^2} = M\frac{dv}{dt} = -P(L, t) \qquad (11)$$

where P is the spring force and v is the velocity of spring end A measured along the spring axis.

Until the concepts of the surge-wave theory were developed by the author, no general solution to Eq (11) was thought to exist which is valid for all mass ratios M/m. Two approximate solutions were developed which were based on simplified assumptions of spring behavior. These formulas are inaccurate for smaller mass ratios and are valueless when describing the case where a precompressed spring is permitted to freely expand ($M = 0$). They are briefly reviewed before discussion of the solution based on the surge-wave theory.

THEORY OF A MASSLESS SPRING

This theory is based on static concepts and neglects the mass of the spring coils. It assumes that all coils are under the same load at the same time, which is equivalent to assuming an infinite velocity of wave propagation. Accelerating force on M is given by the static force P pertaining to the deflection y

$$P(L, t) = Ky \qquad (12)$$

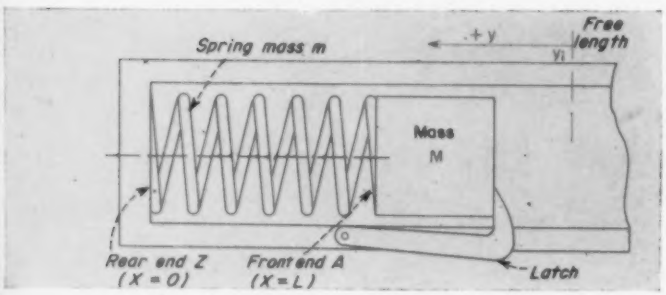
Where K is the static load-deflection rate of the spring

Equation for the surge-wave velocity c in a compression spring is

$$c = \frac{d}{D}\sqrt{\frac{Gg}{2\gamma}} \text{ in./sec} \qquad (1)$$

where d is the wire dia and D is the mean coil dia. For a steel spring where the torsion modulus G is 11.5×10^6 lb./in.^{2} and the specific weight γ is 0.283 lb/in.^{3}, the surge wave will travel through the coils at a velocity of

$$c = 88{,}600(d/D) \text{ in./sec} \qquad (2)$$



1 Schematic arrangement for the release of a preloaded spring and mass.

The surge time T, required for the wave to travel from one end of the spring to the other, is equal to

$$T = \frac{L}{c} = \frac{3.17\,DN}{c} \text{ sec} \qquad (3)$$

where L is the active wire length and N is the number of active coils. For steel springs

$$T = \frac{ND^2}{27{,}900\,d} \text{ sec} \qquad (4)$$

The change in deflection per coil f_d (dynamic deflection) resulting from the surge wave is directly proportional to the velocity v_o of the mass striking the spring

$$f_d = \frac{v_o L}{cN} \text{ in./coil} \qquad (5)$$

This deflection causes a dynamic stress that can be computed from the standard stress-deflection equation for compression springs

$$S = \frac{fGd}{\pi D^2} \text{ psi} \qquad (6)$$

With springs that are struck by a mass or are suddenly compressed, the deflection f in Eq (6) is the sum of the apparant static deflection f_s (the deflection that will occur if the spring is moved slowly) and the dynamic deflection f_d. Thus $f = f_s + f_d$.

and is equal to P/y. From Eqs (11) and (12), mass M while in contact with the spring will perform a quarter cycle of sinusoidal motion

$$y = y_i \sin (t\sqrt{K/M}) \tag{13}$$

The time T_A required to separate the mass from the front end is equal to the quarter-cycle time

$$T_A = \tfrac{1}{2}\pi\sqrt{M/K} \tag{14}$$

At the instant of separation, the entire initial potential energy of the spring is converted into kinetic energy of the mass, and the final velocity v_A of the mass becomes

$$v_A = y_i\sqrt{K/M} \tag{15}$$

For the case where the spring is expanding freely the final expansion velocity approaches infinity. Therefore, Eq (15) is only valid for large mass ratios.

THEORY OF A CONCENTRATED SPRING MASS

With smaller mass ratios M/m, it is obvious that the mass of the spring coils should be considered in deriving the equation of motion. However, more in the way of an empirical method than by a profound and accurate analysis, this led to the assumption of a concentrated spring mass.

Again all coils are assumed to be under the same load, and the distribution of velocity over the spring coils is assumed to be linear ranging from zero at the rear end to the full velocity at the front end. At the instant of full expansion of the spring, the coils no longer contain any potential energy, but still contain a kinetic energy E

$$E = \frac{1}{2}\int v^2\,dm = \frac{1}{3}\left(\frac{mv^2}{2}\right) \tag{16}$$

The kinetic energy in Eq (16) is equivalent to one-third of the spring mass moving at the full velocity. This result suggests to divide the actual spring into two portions: A massless spring having the static characteristic $P = Ky$ of the given spring, and a concentrated inert mass $m/3$ permanently attached to the front end of the massless static spring. Therefore, the same equations are used, Eqs (13) to (15), but with the term $(M + m/3)$ replacing the term M.

EXPANSION ACCORDING TO SURGE-WAVE THEORY

A preloaded spring to be suddenly released alone $(M = 0)$, has an initial potential u. After the spring is released, there are no forces acting on the front end, and the potential becomes zero.

To satisfy the new boundary conditions, the initial potential must be compensated by a left-going extension wave W_L of constant potential amplitude $-u_i$ which enters the spring at A at the moment of release. This wave is propagated through the spring at surge velocity c from Eq (1) and is superposed to the initial status of the spring. The coils affected by this wave then assume a resultant extension velocity which is equal to the potential. Therefore, the spring coils successively extend to a zero potential (zero load and stress) by expanding with a velocity $-u_i$ to the right.

At $t = T$ (the time necessary for the surge wave to travel through the length of the spring) the wave W_L reaches the rear end Z of the spring. The rear end of

---

A new value for measuring the energy potential of a wire element is the potential u which has the same dimensions as velocity. This term which simplifies the analysis of surge waves is analogous to the potential of a vertical column of fluid measured by the velocity of flow at the bottom of the column.

The potential is defined by the equation

$$u = 0.99S\sqrt{\frac{g}{2\gamma G}} \text{ in./sec} \tag{7}$$

From Eq (7) it can be seen that the potential is independent of the spring dimensions. For steel springs Eq (7) can be reduced to

$$u = S/131 \text{ in./sec} \tag{8}$$

Thus, the potential is proportional to the induced stress. It will be shown that a compressed spring when released will 'shoot out' with a velocity equal to the potential to balance the boundary conditions.

SUPERPOSITION OF WAVES

When an unstressed and stationary spring is suddenly compressed with a velocity v_o, each wire element passed by the generated wave will undergo a change in velocity equal to v_o measured also along the spring axis (along direction y in Fig. 1). Each wire element will also increase in stress equivalent to a compression potential $u = v_o$. Thus the kinetic and potential components of a surge wave are equal, and both are measured in in./sec.

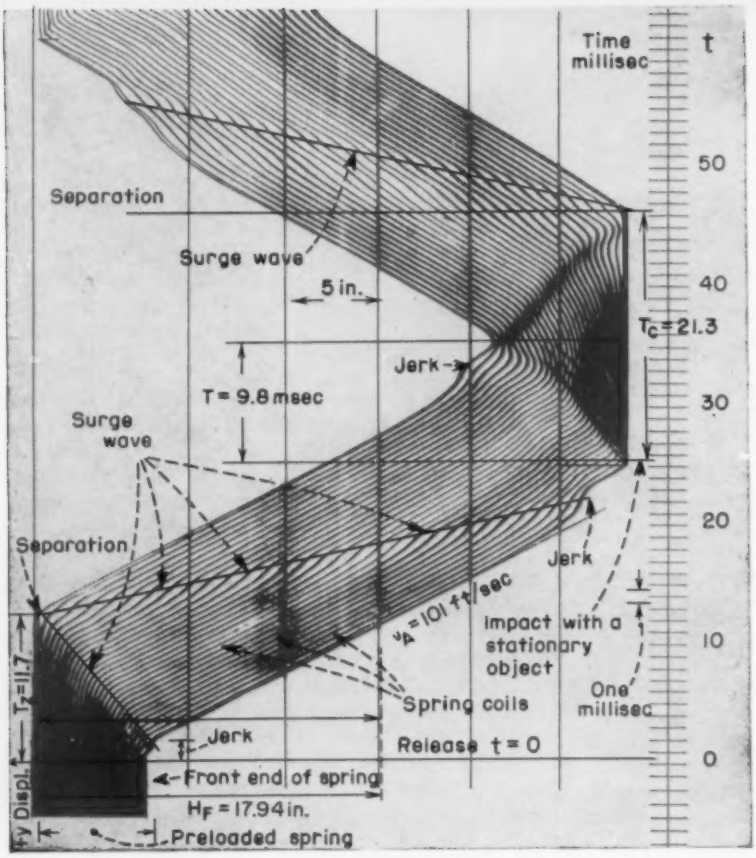
For a wave generated by a motion of the rear end of spring and moving in the opposite direction, the potential component of the wave is equal to the velocity component in magnitude only, but opposite in sign $u_R = -v_R$.

Thus, a spring may have an initial velocity v_i, an initial potential u_i, and both left-going $(u_L = v_L)$ and right going $(u_R = -v_R)$ surge waves. Super-position of the waves onto the initial status of spring is easily described: the resultant velocity v or potential u of a wire element x at a given time t is the algebraic sum of the corresponding individual components

$$v(x, t) = v_i + v_1 + v_2 + \cdots \tag{9}$$

$$u(x, t) = u_i + u_1 + u_2 + \cdots \tag{10}$$

The concept of an infinite spring gives a simplified treatment of wave reflections at the ends A and Z. The finite spring is conceived as being an intermediate part of a spring of infinite length. To satisfy the given boundary conditions, hypothetical single waves are assumed to enter the finite spring AZ at proper times, from the left or right. Thus when a wave encounters the spring end, an exactly similar wave will be reflected back.



2 Time-displacement photograph of the release of a compressed spring taken with a continuously exposed film. Spring is shown preloaded at lower left corner. Each coil of the spring leaves its trace as the film is exposed at a constant rate of time. Right side of illustration carries a time scale. When spring is released at $t = 0$, the front coil expands to the right and at the same time a surge wave travels in the opposite direction. Coils remain stationary until reached by the wave. Spring flies off rear base when wave reaches rear coil. When spring strikes stationary object (at right side of illustration) it will remain in contact the time necessary for the wave to reflect back and forth from front end. Therefore, contact time is approximately twice separation time.

the spring at this moment begins to "jump" from its support. After separation, the new boundary condition of zero potential at the rear end is automatically satisfied by the passing wave W_L; there is no right-going wave.

Thus the dynamic behavior of this spring when suddenly released is fully described by the entering and passing of a surge wave of infinite length and of constant velocity and potential. This means that the spring will extend with a velocity equal to the initial potential u_i which is easily computed from Eq. (8) by using the static deflection in Eq (6) to obtain S. Thus, if a spring is compressed so that it is stressed to 100,000 psi, the spring when released will shoot out with a velocity

$$v_A = \frac{100{,}000}{(131)(12)} = 64 \text{ ft/sec}$$

There is a limit to the extension velocity that can be obtained with a compression spring. The maximum stress that compression springs can be subjected to is approximately 200,000 psi for small wire diameters. This results in a "velocity barrier" somewhat around 130 ft/sec until materials are developed that can be stressed to higher levels.

The time T_z from spring release to separation of the rear end Z from its support is equal to the surge time T as per Eq (4). From Eq (4) it can be noted that the surge time is independent of the stress imposed on the spring. Therefore, two similar springs will jump at the same time when released even if one is compressed to a much higher degree than the other.

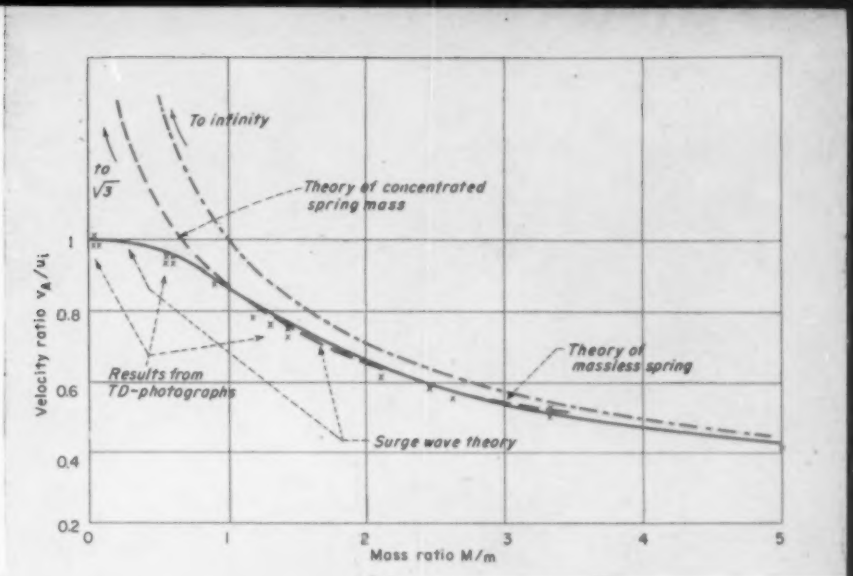
Theory Confirmed by T-D Photograph

Actual behavior of a spring when suddenly released is illustrated in the time-displacement photograph in Fig. 2; the photograph also shows the behavior of a spring when striking a stationary object. The spring has an index of C =D/d = 7.49 which puts it in the medium range. Preloading the spring caused an initial static stress of S_i = 160,000 psi which is equivalent to an initial potential of u_i = 102 ft/sec. Calculated values of other important static and dynamic parameters are compiled in Table I (listed under Spring No. 1).

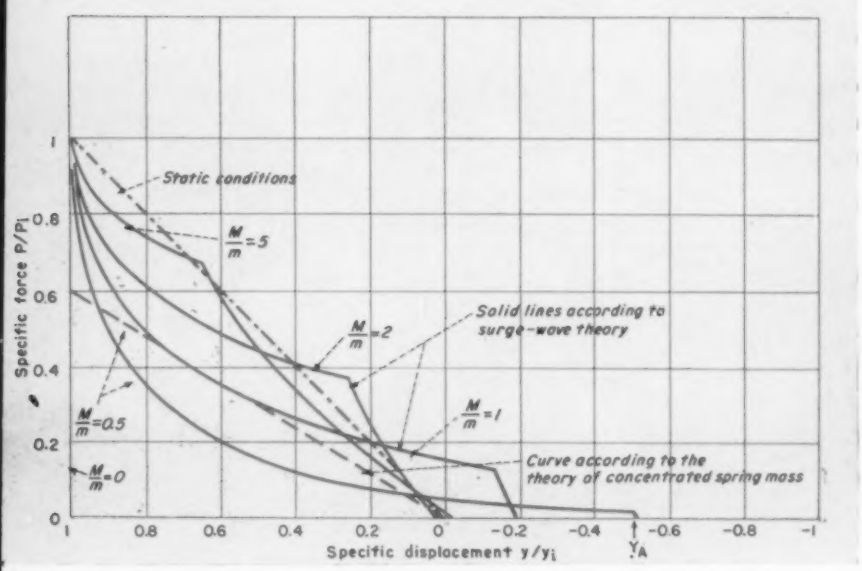
Right-hand side of the photograph carries a time scale in millisec; the horizontal displacement scale has a number of vertical lines traced by markers 5 in. apart. The film passes continually through the camera and the high point of each coil reflects a light to the lens and traces a continuous time-displacement curve of the record on the photograph. The pitch between successive coils can be measured as the horizontal distance between the corresponding traces and the change of pitch indicates the corresponding deflection per coil. By knowing the deflection, the local load P, the stress S and the potential u can be calculated.

From $t = -5$ to 0 the spring remains stationary in its precompressed state. At $t = 0$, front end is released and begins to move immediately. However, it takes one millisec for it to reach its full extension velocity v_A. The velocity is measured at 102 ft/sec, which is in excellent agreement with the value predicted by Eq (8)

$$v_A = u_i = \frac{160{,}000}{(131)(12)} = 102 \text{ ft/sec}$$



3 Chart for determining how fast a precompressed spring will propel a mass. The mass ratio (mass of object M to spring mass m) is known for any given condition. This gives the velocity ratio from the chart. The value for u_i, which is the expansion velocity of the spring under same precompression but with no mass, is obtained from Eq (8). The chart also shows curves based on theories in use today, and results from time-displacement photographs. Note that both other theories give inaccurate results where the mass ratios are small.



4 Dynamic force-displacement curves. For static conditions, the spring force varies with displacement only, and the force-displacement curve is a straight line. For dynamic conditions, the curves vary also with the mass ratio, approaching the static curve when M/m approaches infinity, and approaching two straight lines at right angles when M/m approaches zero.

TABLE I—DATA ON SPRINGS USED IN EXPERIMENTS

	Value	Symbol	Unit	Spring No. 1	Spring No. 2
	Mod. of torsion	G	psi	11,500,000	11,500,000
Basic	Wire dia	d	in.	0.161	0.161
param-	Mean coil dia	D	in.	1.205	1.205
eters	Active coils	N		30.5	17.75
	Free height	H_f	in.	17.94	10.06
	Active weight	mg	lb	0.668	0.38
	Surge time	T	millisec	9.75	5.7
Intial	Initial height	H_i	in.	5.69	6.66
condi-	Deflection/coil	f_i	in.	0.402	0.191
tions	Initial load	P_i	lb	218	105
	Initial stress	S_i	psi	160,000	77,000
	Initial potential	u_i	ft/sec	102	49
Measure	Ext. velocity	v_A	ft/sec	101	47
values	Surge time	T	millisec	9.8	5.8
	Separation time	T_Z	millisec	11.7	——
	Period of vibration	T_c	millisec	——	23.2

From the moment of release a surge wave travels rearward and is reflected at $T_z = 11.7$. At that instant the spring end Z flies off its support. The surge wave traveling to the right shows a gradual increase in amplitude rather than a sudden step-like increase as predicted by theory. This gradual wave head is chiefly caused by a two-step sear release, (the two sear prongs used in the experiment do not release at exactly the same time), and by the inertia effect of the front coil which has mass but no elasticity.

The 11.7 millisec that it takes for the spring to separate from its rear support is about 2 millisec greater than the surge time $T = 9.75$ millisec (computed from Eq (4) with values for N, and diameters D and d obtained from Table I). At $t = 2T$, the weave head again reaches the front end and causes a temporary slowdown (jerk) of the motion of the front end because of the gradual rise in amplitude.

Considering that the gradual release of the spring and the inertia effects of the end coils were disturbing factors, the measured values of extension velocity and

separation time was closely predicted by the surge wave theory.

New Theory Applied to Springs Driving a Mass

Derivation of design equations based on the surge-wave theory for springs driving a mass are rather lengthy and will not be included here. The derivations are based on the fact that the load P is related to the potential u by the following general relation

$$P = mu/T \tag{17}$$

This permits the differential equation of motion, Eq (11), to be transferred to the form

$$T\frac{M}{m}\frac{dv}{dt} = -u_1 - v(t) \tag{18}$$

This differential equation in turn leads to design equations for separation times T_z and T_A, and for the final velocity v_A. As was discussed above, the time required for the rear end of a spring to separate from its support is equal to T when driving no mass. The time increases as the mass ratio M/m increases according to the equation

$$T_Z = T\left(1 + \frac{M}{m}\log_e 2\right) \tag{19}$$

Eq (19) is only valid for separation times $T_z < 3T$ and mass ratios $M/m < 2.89$. The time required for the mass to separate from the front end of the spring is

$$T_A = T\left(2 + \frac{M}{2m}e^{\frac{-2m}{M}}\right) \tag{20}$$

This equation is valid for cases where $T_A < 4T$ and mass ratios $M/m < 5.69$. The final velocity of the mass M at separation from the spring is also valid for M/m ratios up to 5.69

$$v_A = u_1\left(-1 + 2e^{-\frac{1}{2}e^{\frac{-2m}{M}}}\right) \tag{21}$$

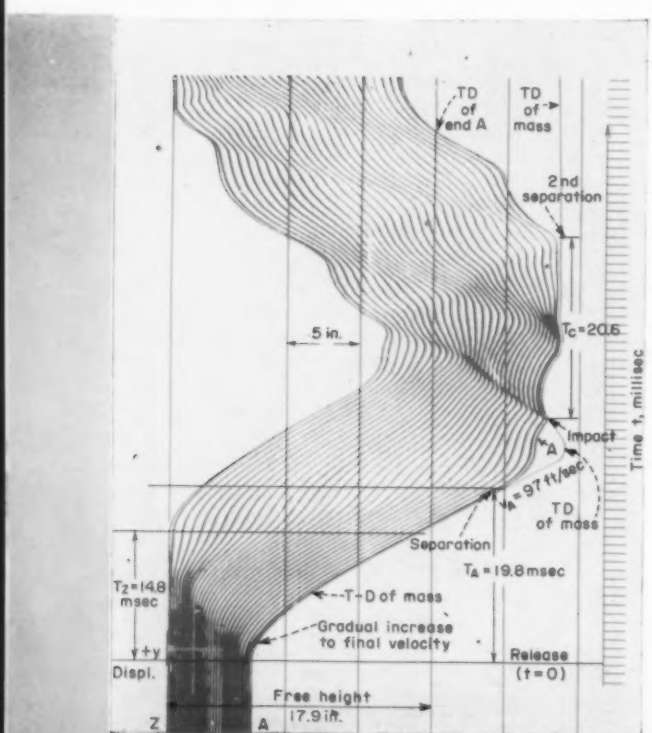
Although Eq (21) is not too difficult to solve, a quick and accurate solution can be obtained by using the chart in Fig. 3. The solid curve gives the final velocity of a mass as a function of the ratio M/m and the specific final velocity v_A/u_1. This curve closes the gap between the case where $M = 0$ and the range of greater mass ratios where simplified formulas are sufficiently accurate. For example, a mass that is one-half that of a spring ($M/m = 0.5$) will be propelled with a final velocity v_A that is 97% of the free expansion velocity of the spring at the same degree of precompression.

For mass ratios greater than unity, the theory of a concentrated spring mass gives very close results while the velocity calculated from the theory of massless springs is inaccurate for mass ratios less than four. The chart also shows the close agreement between velocities calculated from the surge-wave theory and those measured from time displacement photographs.

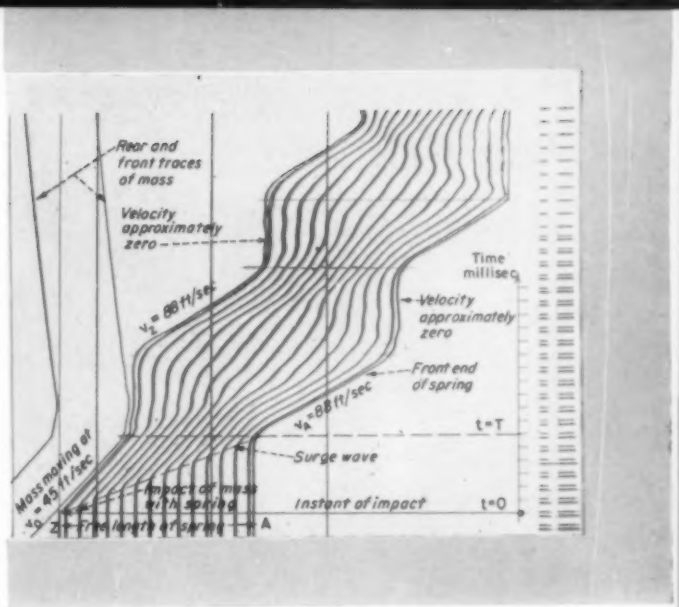
Dynamic Force-Displacement Characteristics

Plotting the force-displacement characteristics of a spring under static conditions will give a straightline curve. In other words, the force will vary linearly with displacement. This static concept is completely erroneous when analyzing the forces in a dynamic spring system. The dynamic force-displacement characteristic of a typical spring is shown in Fig. 4 where the specific force P/P_i (ratio of force to preload) is plotted against the specific displacement y/y_i (ratio of displacement of end A to initial deflection y_i.) A family of curves is obtained by varying the mass ratios. The force-displacement curves approach two limit curves: as the mass ratio is reduced the curves will approach two straight lines, a vertical and a horizontal line for the case $M/m = 0$; as the mass ratio is increased the curves will approach the static characteristic $P = Ky$, which only holds true when M/m approaches infinity.

Thus, the smaller the ratio of the masses, the more concave is the dynamic force-displacement curve. The rapid drop of the accelerating force in the first portion of the extension stroke is caused by the rapid rise in extension velocity which generates a strong extension wave weakening the initial spring force P_i. With small mass ratios, the dynamic force-displacement curves lose any similarity to the static curve. Even the curve based on the theory of concentrated spring mass gives only a



5 Time-displacement photograph of a precompressed spring driving a mass. Spring is released at $t = 0$ and the mass remains in contact with the front coil as spring expands and separates from rear support at 14.8 millisec. At 19.8 millisec the mass separates from the spring. Velocity of spring then decreases until the spring and mass strike an object and rebound.



6 Behavior of an unattached spring when struck by a heavy mass at velocity v_0. The front (right) end of the spring, which remains stationary until the surge wave reaches it, surges forward at approximately twice the velocity of the mass (as predicted by theory). Repeated reflection of the wave causes the velocity of the spring ends to alternate abruptly between 2 v_0 and zero.

crude approximation, as shown when plotted for mass ratio equal to 0.5.

For small mass ratios, the mass is in contact with the spring over an extension stroke y_4 which is considerably greater than the free height of the spring. However, this does not necessarily mean that the spring actually extends to quite such a length since at times the rear end has also moved from the rear support by this time.

T-D PHOTOGRAPH OF A SPRING DRIVING A MASS

Spring No. 1 again has been preloaded to S_i = 160,000 psi and upon release, Fig. 5, drives a 0.40-lb mass, resulting in a mass ratio of M/m = 0.60. Thus all spring conditions are the same as in Fig. 2.

Upon release, the velocity of the front end increases gradually, rather than suddenly, to a final velocity of 97 ft/sec. Eq (21) or Fig. 3 predicts 98 ft/sec. Separation time T_s from the rear end is 14.8 millisec, somewhat greater than the value 13.8 millisec calculated from Eq (19); separation time of the front end is 19.8 millisec compared to 19.6 millisec calculated from Eq (20). In general, all test results are in agreement with theory.

Impact of Freely-Moving Springs

Impact of a freely moving spring against a stop is directly opposite to the case of a suddenly released spring. Instead of the spring having a potential equal to u_i and zero velocity, the spring has an initial velocity v_i and zero potential. From the instant of impact, a left-going compression wave of velocity and potential amplitude $-v_i$ enters the front end of the spring. Coils affected by this wave come to rest and have a compression potential equal to $-v_i$. At $t = T$, the entire spring is at rest and compressed to the potential $-v_i$, its initial kinetic energy having been converted into potential energy. The motion that then follows is identical to a suddenly-released precompressed spring. The velocity of the rear end will change suddenly from $+v_i$ to $-v_i$ with a right-going extension wave traversing the spring from rear to front end.

The time-displacement record in Fig. 2 shows the impact of a spring striking a fixed stop while moving at 101 ft/sec. Although the spring is under the influence of a disturbing wave, caused by the gradual wavehead of release wave, it closely follows the predicted theoretical behavior. Approximately at $t = 2T$ the wave generated by the impact reaches the front end causing it to separate from the stop. Contact time T_c with the stop is 21.3 millisec compared to the theoretical value of $2T$ = 19.6 millisec. Extension velocity of the rear end is close to the initial impact velocity, with the deviation being explained by friction losses.

Sudden Movements in Springs

If one end of an unattached stationary spring is suddenly moved to the right by the impact of a heavy mass moving at a velocity v_s ($v_s < 0$), a right-going surge wave will be produced. The wave will be a compression wave, Fig. 6, with a velocity amplitude equal to v_s and a compression potential equal to $-v_s$. The wave will pass through the spring and reach the right end at $t = T$. Boundary condition at the free right end demands that the potential u be zero at all times. This condition can only be satisfied by having a left-going extension wave, with velocity equal to $+v_s$ and potential equal to $+v_s$, enter the spring at the right end from $t = T$ on. This entering wave can also be called a "reflected wave" and according to Eqs (9) and (10) of wave superposition, the resultant velocity at the right end becomes $2v_s$. Therefore, the right end starts to move at a velocity twice the initial impact velocity of the striking mass.

The photograph in Fig. 6 also shows the repeated reflection of the wave at the ends A and Z, which are both free. Each spring end has alternating phases of velocity changing rather abruptly from $2v_s$ to zero. These reflections are "mirror-images" of the reflection at a fixed end of a spring. At a free end, the velocity amplitudes of the passing and reflected wave add to each other, while the potential amplitudes of the two waves nullify each other. At a fixed end of spring, the velocity amplitudes of the passing and the reflected wave necessarily compensate each other, while the potential amplitudes add to each other.

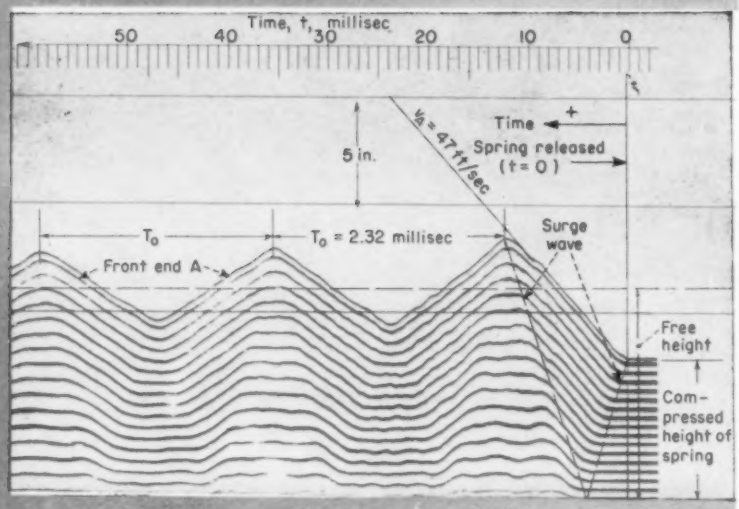
Free Vibrations of Springs

The lowest natural frequency n_1 of a spring attached to a rear support with the front end free to move is inversely proportional to the surge time T:

$$n_1 = \frac{1}{4T} \text{ cycles/sec} \qquad (22)$$

Therefore the period of vibration comprises four surge times.

Under certain conditions of impulsing, such as vibrations caused by the operation of an electric motor,



7 Vibrations in a spring with one end attached to a base. Spring was compressed (at right) and then released. Time is recorded from right to left. Saw-tooth motion of front end A (top end in this illustration) is at variance with the harmonic theory of vibrations which predicts a sinusoidal motion. Actually, all coils undergo abrupt changes in velocity from zero to 47 ft/sec (equal to expansion velocity u_i for this spring) to zero velocity and then to −47 ft/sec.

the spring will have a harmonic mode shape with time-displacement and time-velocity functions that are sinusoidal. Thus the front end of the spring will vibrate sinusoidally with respect to time. In many cases, the mode shape of vibration will be composed of several harmonics.

However, a "saw-tooth" motion will occur in the front end of a spring, Fig. 7, when it is compressed, then released. The saw-tooth motion will approximate a sinusoidal motion after a period of time. This unusual behavior can be conceived as the superposition of two waves upon the initial status of the spring, one travelling to the left and the other to the right. The front end is always free from load and has alternate phases of constant extension velocity $-u_i$ or compression velocity $+u_i$ of same amount, over alternating phases of time $2T$. Each intermediate coil during one cycle undergoes the following phases in status:

1. Compression potential u_i; velocity zero
2. Potential zero; extension velocity $-u_i$
3. Extension potential $-u_i$; velocity zero
4. Potential zero; compression velocity $+u_i$.

The spring in Fig. 7 (Spring No. 2 in Table I) has one end containing additional coils to facilitate fastening into the rear support. Spring was preloaded to 77,000 psi giving an initial potential $u_i = 49$ ft/sec. Results are according to theory. Period of vibration comprises 4 surge times T, the spring vibrating at its fundamental frequency. The measured extension velocity $v_A = 47$ ft/sec is somewhat less than the predicted value of 49 ft/sec but there is evidence of friction losses and damping, such as the increase of spring height at the instants of maximum compression to account for the difference.

If the spring is permitted to continue its vibrations, the original step wave will smooth out and the time-displacement curve of front end A converges toward a sine curve. Evidently, the spring has a natural tendency to dampen out the steep slope of the original step wave.

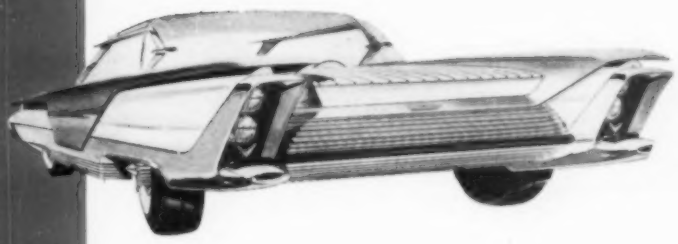
It is interesting to compare velocities obtainable by spring actuation with velocities from other mechanical means. Springs with small wire diameters (say, up to 0.10 in.) can be stressed as high as 200,000 psi equivalent to an initial potential $u_i = 128$ ft/sec. Therefore, light masses in the order of magnitude of the spring mass itself can be propelled to velocities slightly above 100 ft/sec. With wire diameters greater than 0.10 in., the maximum permissible stresses are somewhat less, but still permit the acceleration of light masses to 100 ft/sec.

The historical longbow shoots an arrow at a velocity of about 140 ft/sec, while the modern flatbow developed by scientific research propels the arrow up to 200 ft/sec. In technical applications, the sudden contraction of a pre-stretched shock-cord composed of many rubber fibers will accelerate a light mass up to 250 ft/sec.

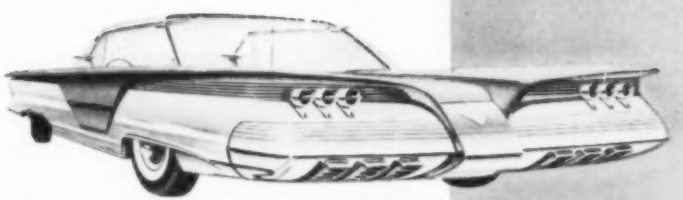
The spring behavior in Fig. 7 may seem to contradict the harmonic-wave theory which is the basis for vibration analysis. However, any standing harmonic wave can be conceived as being the product of superposition of two identical sinsuoidal surge waves moving in opposite directions (see Eqs (65) and (66), March 1955, page 172). But the reverse is not always true: A given surge wave usually cannot be represented by a sum of standing harmonic waves. Therefore, it becomes evident that the concept of the transient wave is more general than the concept of the standing harmonic wave. The reluctance to accept the surge-wave theory in some fields as the proper method for wave analysis is mostly the result of the historical development of the harmonic-wave theory, which originated in the field of vibrations and continuous motion, rather than with shock and impact. This theory has been quite successful in the study of vibration phenomena, and has pointed out methods for the correct design of machinery by avoiding the ranges of resonance. However, the field of shock and impact is a field of transient waves, and the surge-wave theory a more fundamental theory, permitting a more rapid analyses of the problems.

EDITOR'S NOTE: Fundamentals of the surge-wave theory were first published by Dr. Maier in Part II of a two-part series on *Dynamic Loading of Compression Springs*, January 1954 page 162 and March 1955 page 162. The first article is an introduction to dynamic loading and outlines why static concepts fail to accurately predict spring behavior.

Automotive designers recently received these graphic suggestions from Kaiser Aluminum, based on applications in other fields. The idea was, of course, to show how to . . .



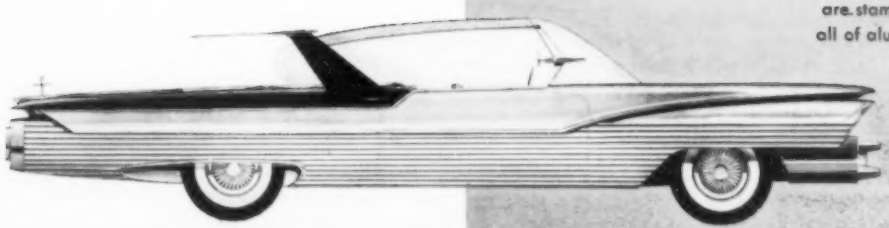
DESIGN FOR ALUMINUM



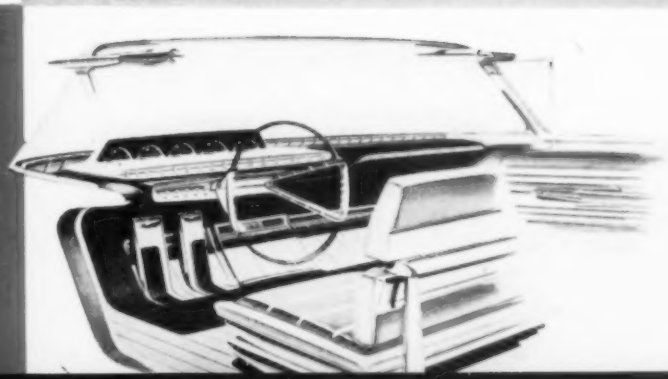
"Del Mar" has semi-concealed headlights (above) behind a bumper-grille extrusion with slots for engine air and a leading edge of molded rubber. The rear (left) features cast or extruded deck and fender sections, also cast center and end bumper sections and exhaust pads. Ornamentation is integral with components.

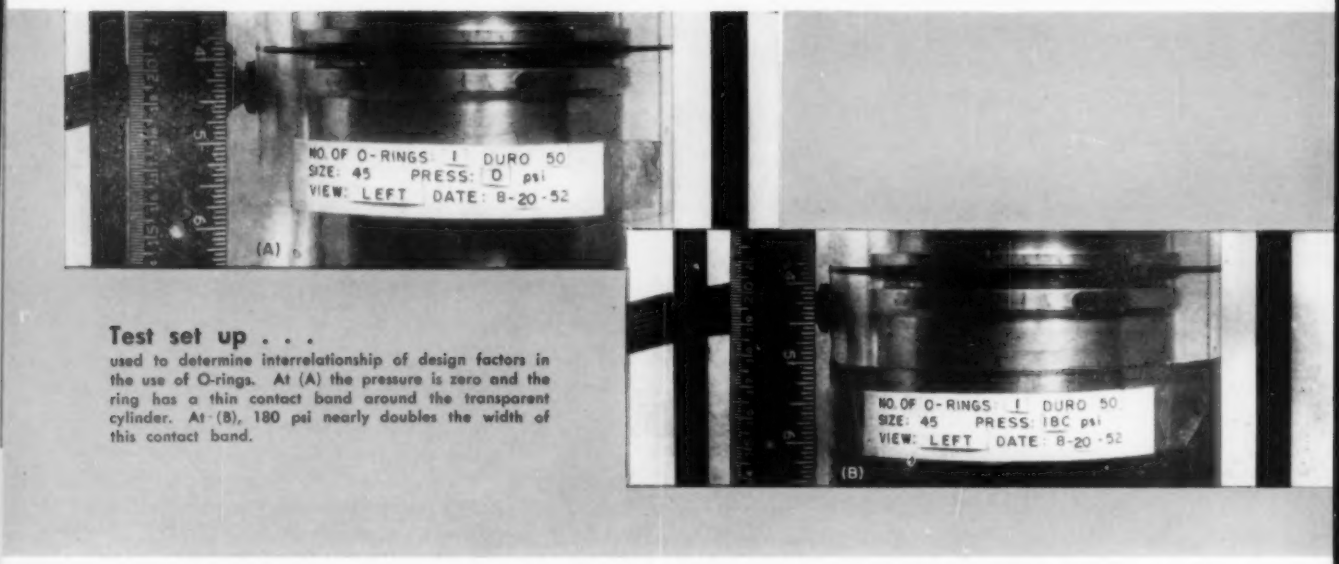
Roll-down doors of narrow extrusions are interlocked with flexible, weatherproof joining strips, color-anodized for texture and continuity of styling. Hood and rear deck could be similarly made. Sliding rear windows and canopy ease entering the "Golden Gate." Wheel wells are aluminum stampings, ridged with colored vinyl hollows. Upper structure is bright anodized aluminum; lower panels, painted steel.

Extruded aluminum panels, in various colors and textures, are fluted to accentuate the long, low sweep of the "Granada." Wheel wells are stamped, bumpers and wheels cast, all of aluminum. Wheel hubs and brake drums are integral.



Firewall, toe-board and panel parts are aluminum castings, textured to make carpeting unnecessary. Seat frame is forged for sculptured styling and lightness. Inner door panels have cast-in texture and trim. Some designs have die-cast doors, cast frames, instrument panels. Weight saving over-all is estimated at 1000 pounds.




NO. OF O-RINGS: 1 DURO 50
SIZE: 45 PRESS: 0 psi
VIEW: LEFT DATE: 8-20-52
(A)
NO. OF O-RINGS: 1 DURO 50
SIZE: 45 PRESS: 180 psi
VIEW: LEFT DATE: 8-20-52
(B)

Test set up . . .
used to determine interrelationship of design factors in the use of O-rings. At (A) the pressure is zero and the ring has a thin contact band around the transparent cylinder. At (B), 180 psi nearly doubles the width of this contact band.

HOW TO APPLY O-RINGS

JOSEPH G. ADILETTA
Assistant Laboratory Manager, General Engineering Laboratories
American Machine & Foundry Company

Test program develops simplified principles for proportioning mechanical parts to achieve maximum sealing at minimum cost. Type of sealing required dictates seal choice. Effect of factors such as fluid pressure, surface finish and eccentricity of shaft and cylinder on initial "squeeze," cross-section ring diameter, and Durometer of rubber.

Successful use of O-rings is dependent on the particular physical and dimensional characteristics of the application. For this reason, it is essential that the basic theory and principles underlying manufacturers' formulas and recommendations be understood, to determine whether they apply to a particular application, and to provide a sound basis for necessary deviation.

Tests to analyze the influence of significant variables were conducted on an application in which the slightly oversize cross-section rings fit a retaining groove around a piston. Several simplified principles have been determined for proportioning mechanical parts to achieve maximum sealing at minimum engineering and manufacturing costs.

DESIGN FACTORS

Tests established criteria for determining the interrelationship of a number of variables. Fig. 1 shows a typical application. Here is a brief discussion of these variables and their fundamental relationships:

Initial Ring Compression (squeeze)

Prior to application of fluid pressure, the O-ring must be compressed between the sealing surfaces. The amount of initial compression is determined by the individual configuration. Although a greater initial squeeze results in a tighter seal, a tighter seal has more friction in sliding applications, greater backpressure in static ones. It is therefore necessary to provide the proper squeeze without disturbing other factors equally important.

Shaft and Cylinder Dimensions

The ring is selected to fit the shaft groove with a slight stretch. For example:

(1) Shaft diameter: 3.990 ± 0.003 in. (±0.005-in. eccentricity)

(2) Cylinder Diameter: 4.000 ± 0.003 in. (±0.005-in. eccentricity)

(3) Material: steel

(4) Pressure: 200 psi

(5) Surface Finish: 32 microinches rms (radial only)

O-ring selection had been made thus:

(1) Outside diameter: 4.000 in. (with allowance for slight reduction in cross-section diameter because of the 0.002-in. nominal stretch and manufacturing tolerances).

(2) Cross-section diameter: 3/16 in. (assumed nominal cross section; actual dimension 0.210 ± 0.005 in).

(3) Inside diameter: OD of O-ring minus two times the cross-section diameter (but less than groove diameter).

(4) Rubber Durometer: 60 (selected because of average surface finish and medium to high fluid pressures involved).

Groove diameter = cylinder diameter (4.000 in.) minus two times nominal cross section diameter of ring (0.210 in.) plus two times average cross section diameter tolerance (0.005 in.) plus allowance for stretch (0.002 in.) plus possible shaft eccentricity or displacement (0.005 in.) plus average of shaft and cylinder tolerances (0.003 in.) plus two times initial squeeze (S).

Groove Diameter = $4.000 - 2(0.210) + 2(0.005) + 0.002 + 0.005 + 0.003 + 2S$.

Groove Diameter = $3.600 + 2S$.

With a 0.010-in. squeeze (shown by tests to be the minimum practicable): minimum groove diameter is 3.620 in. For a 0.020-in. squeeze (upper limit in normal application): groove diameter is 3.640 in. Thus normal squeeze range is 0.010 to 0.020 in., groove-diameter range is 3.620 to 3.640 in.

In actual practice, the unknowns in the above example (squeeze and groove diameter) may be replaced with assumed required specifications, and the formula used to solve for other unknowns.

Cross-Section Diameter of the O-ring

Manufacturers' O-ring stock sizes show an increase in cross-section diameter as nominal diameter is increased, as shown in Table I.

Table I

Nominal Ring Dia, in.	Cross-Section Dia, in.
Up to 1/16	1/32
Up to 3/8	1/16
Up to 3/4	3/32
Up to 1-1/2	1/8
Up to 4-1/2	3/16
Over 4-1/2	1/4

A general formula follows which is a logical approach for establishing O-ring dimensions. This formula is not meant to be used in solutions using quadratics or matrix techniques for simultaneous multiple equations, but it is useful for the cut-and-try solution. Unknowns in each application must be reduced to one by assuming a value for the other unspecified variables. After an acceptable solution for the one unknown, the other factors can be varied and alternate solutions made until all factors are satisfactory.

Assume:

(1) Mfg tolerances. ±0.010 in.

(2) Surface finish: 32 microinches rms

(3) Eccentricity: ±0.005 in.

(4) Pressure (for squeeze importance): 150 psi

(5) Ring-manufacturing tolerances: ±0.005 in.

(6) Ring diameter: 3.008 in.

Cross-section diameter = K + (mfg. tolerances) + (eccentricity) + (ring manufacturing tolerances) − (squeeze); where K = actual cross-section diameter listed in Table I and the ring is equal to nominal dimension

Cross section = $K + 0.020 -$ squeeze

Cross section = $0.210 + 0.020 -$ squeeze

Squeeze required is established as a function of the fluid pressure, Durometer, and surface finish. For this case, a squeeze of 10% is satisfactory for a Durometer of 70 and surface finish of 32 microinches.

Optimum cross-section diameter = $0.210 + 0.020 - 0.021 = 0.209$

= 3/16-in. nominal cross section

Although these are standard dimensions, it is often economical to have special molds for larger cross-section rings. For example, a ¾-in. cross section should be considered with a 20% squeeze to enlarge the groove-to-cylinder manufacturing tolerances, thereby reducing the manufacturing cost. Such a ring can also compensate for somewhat excessive eccentricities between shaft and cylinder.

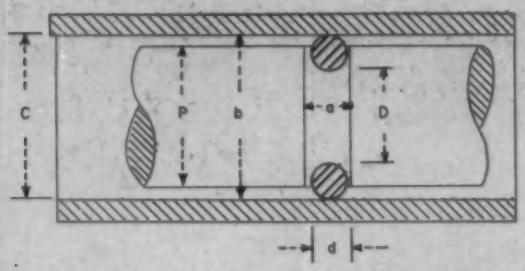
Rubber Hardness (Durometer)

Rubber is identified by a standard stamping system explained in Table II. The Durometer is an index of the resistance of an elastic material, such as rubber, to a standard pressure. A Durometer of 30 represents an exceedingly soft rubber, whereas a 90-Durometer rubber has a resistance to hand pressure approximately equal to that of wood. (Fig. 2 shows the results of friction vs Durometer tests.) Commercially available O-rings range from 60-70 Durometer. Rings with a hardness beyond this range may be obtained on special request.

The Durometer selected always should be as low as the particular application will permit. The choice is influenced by: pressure of the fluid being sealed, cross-section diameter of the O-ring, the importance of friction, and surface finish. For pressures below 200 psi, 50-60 Durometer should be considered standard and other variable factors adjusted accordingly. Up to 1500 psi, 70 Durometer O-rings may be used. Softer rubber will seal surface imperfections more effectively at a given fluid pressure. For surface finishes of 64 microinches rms, a ring with a minimum cross-section diameter of ¼ in. should be used.

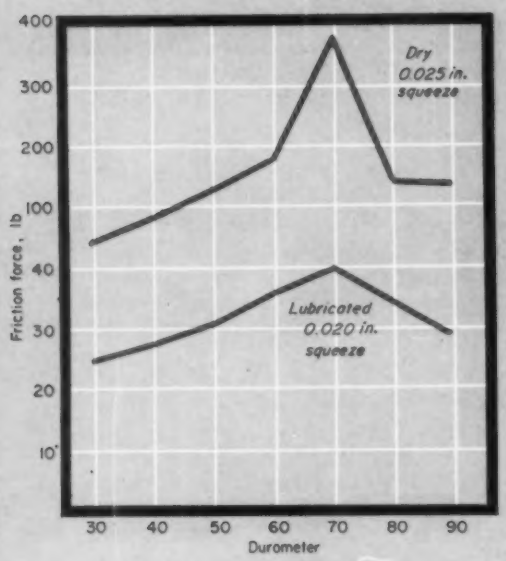
Fluid Pressure in the Cavity

The tolerance of mating parts and the rubber Durometer selected are greatly influenced by the pressure



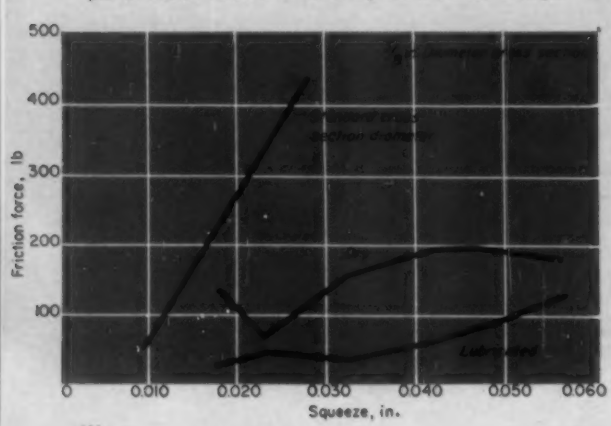
a—*Groove width*
b—*Free ring od*
C—*Cylinder dia.*
P—*Piston dia.*
d—*Ring dia. cross section*
D—*Ring nom. dia.*

1 O-ring application . . .
plus main design dimensions and their symbols.

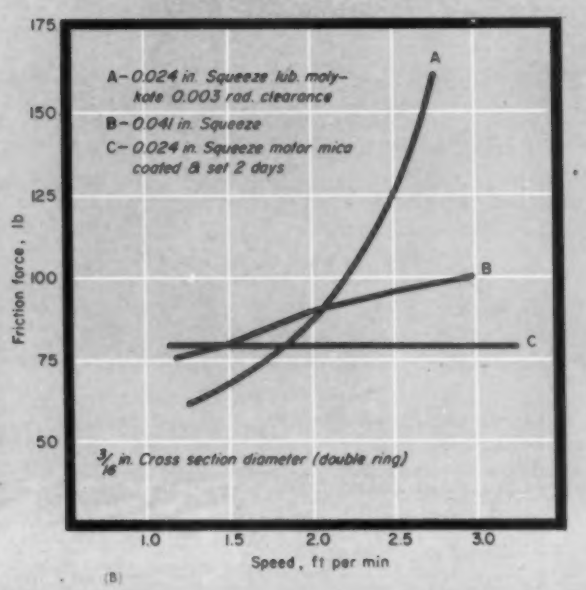


2 Friction versus Durometer . . .
test of a 3/16-in. dia cross-section O-ring both dry and lubricated.

3 Friction force . . .
as a function of squeeze (A), speed (B), and (C) a comprehensive plot of friction forces for various dry and lubricated O-rings.



(A)



(B)

of the fluid being sealed. High pressures may require a closer fit between the cylinder and shaft or piston, a higher Durometer rubber, increase of the cross-section diameter of the ring, or addition of back-up rings behind the O-ring seal. However, if the rubber Durometer is carefully selected to accommodate the expected range of pressures, and all other variable factors are properly adjusted to it, an excellent design should result.

Surface Finish and Impurities

Surface finish specified for the sealing areas should take into account fluid pressure, sliding friction, amount of squeeze, and rubber Durometer. If the sealed fluid contains impurities, the surface of shaft or cylinder will be subject to abrasion which can destroy the seal and allow fluid to leak past the ring.

Set up regular inspections for scratches in the sealing areas, even if the visible surface areas exhibit no evidence of this condition. A surface finish of 32 microinches rms should be satisfactory if 50-60 Durometer is used and no abrasive particles are present. If a harder rubber is indicated, such as 70-80 Durometer, and the cross-section diameter is not special, surface finish should be improved to 16 microinches.

Eccentricity of the Shaft and Bore

If the shaft and cylinder diameters are not concentric, there will be more O-ring squeeze on one side and less on the opposite side. Maximum clearance should be checked and the O-ring designed to be squeezed a maximum of 15-20% on the tight side. Where conditions make concentricity costly or difficult to obtain, an oversized O-ring should be considered. This will provide a greater range of diameters for satisfactory sealing.

Static vs Dynamic Application

A static application is one in which the seal is mounted between non-moving parts. This could be a

shaft-cylinder design or bolted-cap assembly. For static conditions, the squeeze can be greater and tolerances on surface finish are not as critical. Factors discussed above still apply, but much greater latitude can be permitted in choosing the limits of the related factors.

Friction and Lubricants

Friction force is proportional to the coefficient and the normal pressure between the sliding surfaces. The coefficient of friction is affected by the Durometer of the ring, surface finish, and lubricant used. Normal pressure between the sliding surfaces is a function of the ring Durometer, the amount of squeeze, and the fluid pressure. As in all engineering developments, some of these factors can be chosen by the designer, and some are dictated by other requirements. By recognizing these relationships, it is possible properly to balance the factors to achieve the optimum design. In Fig. 3, the results of tests varying the squeeze and lubricants are compared.

SEALING THEORY

When an O-ring is compressed between two surfaces, the initial squeeze causes the ring to behave as a confined fluid under pressure to resist the contained pressurized fluid tending to pass it. Effective sealing will result only when squeeze is uniform around the ring, when inside surfaces of the cylinder are smooth, and when contact pressure of the ring exceeds the fluid pressure. As the contained pressure increases, rubber-contact pressure must increase proportionally to maintain the seal. In an effective O-ring installation, fluid pressure deforms and tends to extrude the ring, forcing it against the contact surfaces and tightening the seal. Thus, effectiveness of the seal increases as a direct function of applied pressure.

The area of the O-ring exposed to fluid pressure must be greater than the area facing the ambient or reduced pressure so that the deformed rubber will be pressed outward against the cylinder. The combined effect of radial and transverse forces make it possible for the O-ring to withstand from 500 to 3,000 psi, with an initial contact squeeze of perhaps only 1 psi on the rubber.

Excess pressure, however, can extrude the ring through the clearance between the shaft and cylinder. To prevent this, rings may be formed of harder rubber, clearance between shaft and cylinder may be reduced, or backup rings may be employed.

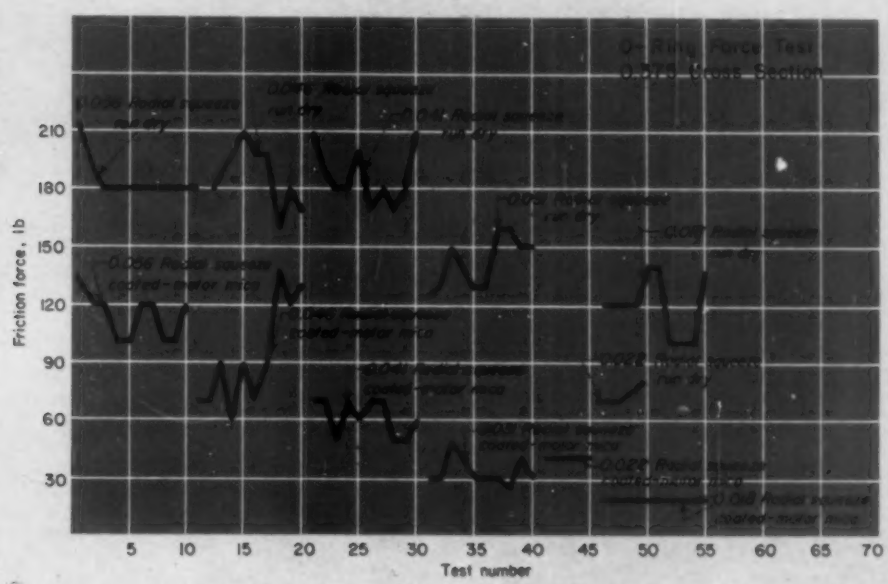
To derive maximum benefit from the self-adjusting qualities of O-ring applications, ring rubber hardness should be selected in accordance with the pressures to be encountered. If the size of the O-ring groove in the shaft can be increased, using a ring with a greater cross-section diameter will allow a corresponding increase in acceptable tolerances and a decrease in rubber Durometer.

Interrelation of Factors

Sealing is achieved because of the normal (perpendicular) force created when an O-ring is squeezed. This force is proportional to rubber hardness for a given dimensional squeeze. For example, 0.010-in. squeeze on 80-Durometer rubber has greater normal force than 0.010 on 30-Durometer rubber. Note that if squeeze is sufficient to withstand pressure without deformation, surface finish of the parts is more critical when a harder ring is installed.

If these factors are satisfactorily resolved, clearance and eccentricity controlling uniformity of squeeze are the next important variables to be considered. "Resistance to set" (one side squeezed more than other and beyond the elastic limit) and normal force variation of the compound are significant in this connection.

If the units to be sealed are relatively static (bolted, etc), clearance between shaft and cylinder may be in-



creased, provided the assembly is centered before bolting. In this case, amount of extrusion becomes a factor and clearance is acceptable only up to a certain pressure relative to Durometer. For example, 15% of the cross-section diameter of the ring should be a safe clearance up to 500 psi, with no deformation. Based on rubber-deformation sealing theory, this figure would be modified to permit a desired amount of extrusion to take place by altering the clearance-Durometer-pressure relationship.

The "Check Valve" type of sealing (excellent for static seal) may be achieved with a Durometer less than 70 for pressures less than 500 psi and clearances in proportion to pressure and Durometer.

DESIGN FACTORS

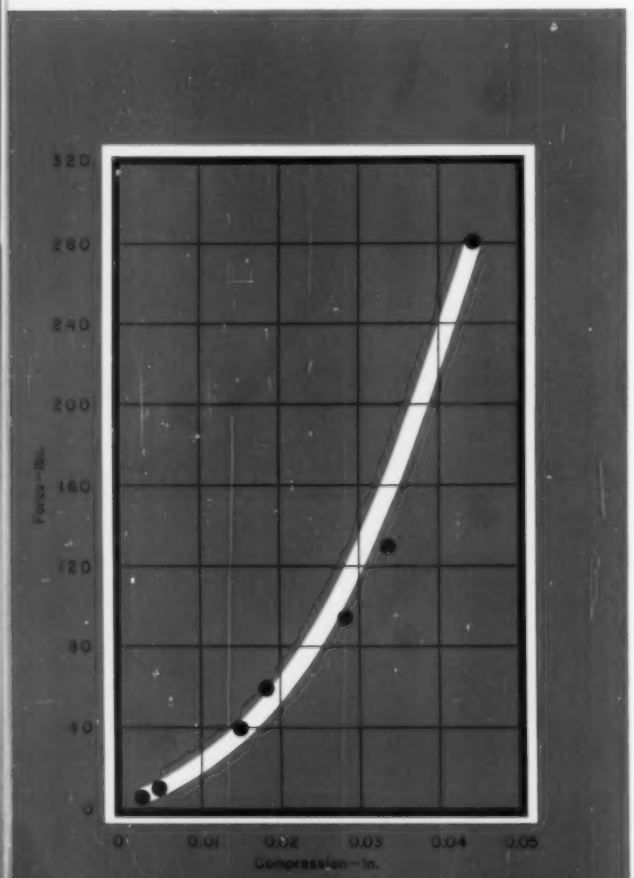
It is possible to install an O-ring which will compress on either its ID or OD by dimensioning the piston or shaft groove OD equal to the at-rest ID of the ring or the cylinder with an ID equal to the nominal OD of the ring. The mating part will then compress the O-ring at installation.

If the ID of the cylinder corresponds to the OD of the O-ring, and the OD of the retaining groove in the shaft or piston corresponds to the ID of the O-ring, there will be no squeeze when the piston is assembled into the cylinder. (Even this type of assembly would seal effectively, although some leakage may occur during the pressure buildup.) As soon as the pressure is sufficient to force the ring into the clearance space between the piston and cylinder, the seal functions like a check valve, as though originally designed with proper squeeze.

To avoid low-pressure leakage, the mechanical design and the dimensions involved should be such that the rubber is compressed between the piston and cylinder before the pressurized fluid contributes to the squeeze.

If the amount of squeeze were held constant for all cross-section diameters, it would represent a larger percentage of a $\frac{1}{16}$-in. cross-section diameter O-ring than of a $\frac{1}{4}$-in. cross-section diameter ring. On the other hand, if a constant percentage of diameter were used for design, the advantage of some applications would not be achieved. Therefore, for rings $\frac{1}{8}$-in. cross-section diameter and smaller, a 10-15% figure may be used, but for larger rings, actual dimensions should be used to fit the application.

The main advantage of using dimensions instead of percentages of squeeze is that various factors affecting sealing may be adjusted for before the parts are dimensioned. If the 10% rule is applied exclusively, risk and cost factors may be overlooked.



4 Force squeeze plot . . . of an O-ring of 4.000 in. nominal OD, 3/16-in. cross-section diameter and 80 Durometer hardness.

DESIGNING A TYPICAL INSTALLATION

Initially, certain factors are known and others can be established. Fluid pressure which will be encountered and type of application (static or dynamic) are predetermined. For this example, consider a dynamic shaft-to-cylinder application with low pressures. Shaft and cylinder dimensions are calculated for a 4-in. O-ring installation, and eccentricity of the shaft and cylinder assumed standard relative to tolerances on the parts.

The next step is to establish a basic surface finish which is standard for an application of this type and economical to apply, such as 64 microinches rms. The lubrication requirements depend on whether the fluid to be sealed is a natural lubricant (water or hydraulic oil).

The remaining variables may then be determined thus:

Initial pressure or squeeze required is primarily based on fluid pressure to be sealed and component dimensions. Designed squeeze must be sufficient so that the rubber's resistance to compression exerts a pressure on the cylinder wall greater than that of the fluid being sealed. (Stress-strain characteristics of 50-Durometer rubber compound are given in Fig. 4). The cylinder and shaft should then be dimensioned to provide the required compression.

Cross-section ring diameter used is governed by the squeeze determination. Amount of squeeze will dictate what diameter is required to fall within percentage limits described in the previous section. Surface finish must also be considered when determining cross-section diameter, but in this case it is assumed to be free of imperfections.

Friction is a function of squeeze and lubricants

TABLE II—RUBBER IDENTIFICATION (SAE-ASTM—MIL-R-3065)

SB - 5 12 - A3C

BASE POLYMER**

RN — Natural or Redaim (Non Oil Resistant)
RS — Synthetic — GR-S (Non Oil Resistant)
SA — Synthetic (Not in General Use) (Maximum Oil Resistance)

SB — Synthetic — Buna N (Good Oil Resistance)

SC — Synthetic — Neoprene (Fair Oil Resistance)

HARDNESS
Grades — Durometer (Shore A) Note 3

3 — 30 ± 5
4 — 40 ± 5
5 — 50 ± 5
6 — 60 ± 5
7 — 70 ± 5
8 — 80 ± 5
9 — 90 ± 5

Tensile Strength (2nd and 3rd Digit) Note 3

00 — Not Required
03 — 300 psi
06 — 600 psi
09 — 900 psi
12 — 1200 psi
15 — 1500 psi
18 — 1800 psi
20 — 2000 psi
25 — 2500 psi
30 — 3000 psi

** The classification of the compound is determined by the predominating basic material therein.

SPECIAL CHARACTERISTICS (to be met when indicated)

A — Oven-aging requirement	(Note 1)
B — Low-compression set requirement	(Note 1)
C — Weather-resistance requirement	(Note 2)
D — Load-deflection requirement	(Note 1)
E — Oil-aging requirement	(Note 1)
F — Flexible at −40 F	(Note 1)
F-F — Flexible at −70 F	(Note 1)
G — Max. resistance to tear	(Note 2)
H — Max. resistance to severe flexing	(Note 2)
J — Superior abrasion resistance	(Note 2)
K — Adhesion requirement	(Note 2)
L — Max. resistance to moisture absorption	(Note 2)
M — Max. resistance to repeated impact	(Note 2)
N — Max. flammability resistance	(Note 2)
P — Min. staining effect on enamel and lacquer	(Note 2)
R — Indicates a resilience test requirement	(Note 2)
Z — An additional lab. test over those designated by the suffix letters listed above, or life or performance requirement	(Note 2)

Note 1. Values required and test methods are covered in specifications.

Note 2. Values required and tests shall be arranged between purchaser and contractor.

Note 3. The indicated digits covering hardness and tensile strength also set up certain elongations to be met.

employed. Once the squeeze is established, the amount of friction is a function of the lubricant, in this case, probably not significant.

Choice of Durometer is influenced by fluid pressure, surface finish, and shaft and cylinder eccentricity. As previously stated, the Durometer selected should be as low as the installation will permit. In this example, considering the nominal fluid pressures, normal surface and minimum eccentricity of shaft and cylinder, a reasonably soft rubber of about 60 Durometer could be used.

Under normal conditions, using standard design practice and standard O-rings, the squeeze would be approximately 10% of the cross-section diameter of a small O-ring. Friction is proportional to the percentage of compression and it can be minimized by reducing radial pressure.

If higher fluid pressures are involved and, at the same time, friction between O-ring and cylinder must be minimized, increasing the cross-section diameter of the O-ring or changing the lubrication will help to reduce friction.

When surface imperfections are a significant factor, a larger cross-section diameter ring will often cover or seal imperfections. The larger O-ring has a greater area of contact and should be considered in applica-

tions where sealing surfaces are unusually rough. Use of a larger cross-section diameter ring, however, is always dependent upon space requirements and other design factors. When an increase is not possible, a decrease in rubber Durometer will help to overcome leakage past surface imperfections, although any such change would necessarily be regulated by the fluid-pressure limits of the application.

OBSERVATIONS MADE DURING TEST

Compression set characteristics are a function of the rubber compound. It is possible to specify any desired compression set by choice of appropriate compound though hardness will change accordingly.

Compression set is based on permanent depression after release of pressure following each specified load compressing to a certain percentage of cross section.

Durometer	Set
30	40%
50	30%
70	25%
90	20%

Set is $\frac{1}{2}$" minimum and shown as a percentage of original specimen dimension.

A 90 Durometer ring appears to take a set more easily, and the initial stretch at installation may be harmful. Temperatures up to 180 F should not affect characteristics, but at temperatures over 250 F most compounds are unstable and set characteristics will vary.

Age increases the Durometer of O-rings. The rate of increase varies with the initial hardness. A 30-Durometer ring will increase to 40 Durometer more quickly than a 70-Durometer to 80. The rate of Durometer increase depends on temperature, exposure, and initial hardness. Judging from field experience, a shelf life of a year is not considered harmful.

Friction experiments with molybdenum disulfide (MoS_2) and electrofilm, on O-rings and inside cylinder walls, proved ineffectual. Molybdenum disulfide compounded in O-ring material showed no apparent surface smoothness and made no significant decrease in friction forces. Powdered MoS_2 was an effective lubricant as long as it remained in place.

Baking a film of molybdenum disulfide on O-rings did not satisfactorily reduce friction. The bond was inadequate and the film flaked off, Fig. 5, impeding operation of the parts.

Surface-finish differences made no sufficient changes in friction force with equal ring squeeze against 5, 32, 63, and 200 microinch rms. However, the O-ring surfaces were scored and damaged by the 200-microinch rms. Harder rings, such as 90 Durometer, chipped easily and damaged under adverse conditions. This characteristic appears serious in consideration of sealing applications using the higher-Durometer rings. On the extremely soft rings, abrasion or chipping is unlikely but pinching is possible and wedging often follows and pulls the ring out of the retaining groove. Scores, nicks, and the like on soft rings do not seem detrimental to sealing effectiveness once the ring is installed. A 35-Durometer ring exhibited perfect sealing qualities with $\frac{3}{8}$ x 1/16-in. scratches. The relationship of surface defects to sealing effectivity follows a definite trend in the range of 30 to 90 Durometer, with a critical point at 70 Durometer.

EDITOR'S NOTE: Recent articles on the design and application of mechanical seals include:

"Gasketed Joints for Electrical Equipment," March 1957 page 183. This article covers the design criteria, characteristics of ideal gasket material, 8 common material types, 18 basic joint designs, maintaining tightness, cementing, splicing and assembly.

"Rotating Seals for High Pressure," February 1956 page 140. Effect of hydraulic balance, structural design, packing and seal face materials on selection of rotating mechanical seals for severe operating conditions.

"High Temperature Seals," January 1956, page 151. Factors affecting design of glands for sealing reciprocating or rotary motion under extremes of heat and pressure; seal material, gland design, lubrication and surface.

5 Baked film . . .
of molybdenum disulfide on O-rings chipped and flaked in use.

A *Product Engineering*
SPECIAL REPORT

Forged and machined gear (left) and three successive redesigns for metal powder. In final design (right) higher density permitted reduction in tooth width and elimination of web.

design for METAL-POWDER PARTS

Robert Talmage *Consultant, New Canaan, Conn.* • **John Kolb** *Associate Editor, Product Engineering*

Product designers are turning to powder metallurgy at a rate that has caused iron-powder consumption alone to multiply more than fivefold in only eight years. Since 1937, when the first sintered steel parts were produced in this country, tens of thousands of structural applications have been found for metal powders.

There is solid basis for putting powder metallurgy to work. The process ties up proportionately less money in equipment, requires less manpower, saves material. Peculiar alloy combinations and structures, with unusual characteristics and properties, are possible. So are shapes that could not be fabricated in one operation.

Why then is powder metallurgy only now becoming self-sufficient? Most sintered parts were formerly made by the older techniques, and the switching was done in rather routine fashion, without taking full advantage of the possibilities in powder metallurgy; the information needed to design such parts "from scratch" has not been generally available.

This report is a start toward presenting such data. Because a relatively new process and material are involved, few exact mathematical values can be included. Instead, the emphasis here is on the engineering philosophy and general considerations applying to such elementary factors as part volume, weight, dimensions, shape and density as they occur in each component designed for the process.

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METAL-POWDER PARTS

Like all production methods, powder metallurgy imposes limits on part size, shape, characteristics and properties. One such limiting factor is the relatively high pressures required to compress powders into three-dimensional shapes. Under pressure, these powders flow as very weak solids. They do not follow the laws of hydraulic flow.

The pressure required for compaction is directly proportional to the cross-section of the part. For example, a cylinder 1-in. long and 1-in. dia requires a pressure of about 25 tons per sq in. The pressure exerted on the part itself, with an area cross-section of 0.785 sq in., would be approximately 20 tons.

Even this 20 tons is exerted only on the layer of metal powder immediately beneath it, because radial forces produced by this axial pressure develop considerable die friction. This friction, which is directly proportional to the applied pressure, reduces the pressure down through the compact as the distance from the punch face increases. This results in an uneven interparticle structure, with high density in one section of a briquet and low density in another. Friction is also developed during ejection of the part from the die. This friction is proportional to the density obtained.

Proper part design can keep variations in density within acceptable limits. Variations are also minimized in modern metal-powder presses by applying compacting pressure to both top and bottom of the compact.

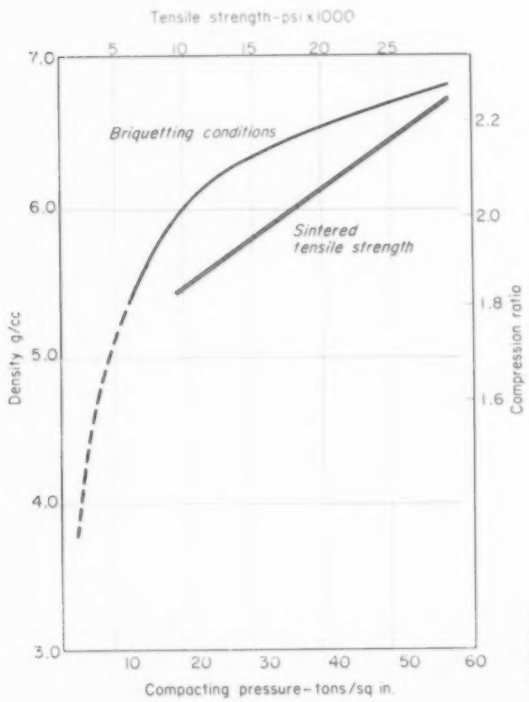


Fig. 1—A curve such as this one (for a low-carbon sintered steel) can be constructed for any metal-powder mixture, indicating range of mechanical properties obtainable in the finished part by varying briquetting conditions.

HOW DENSITY IS CONTROLLED

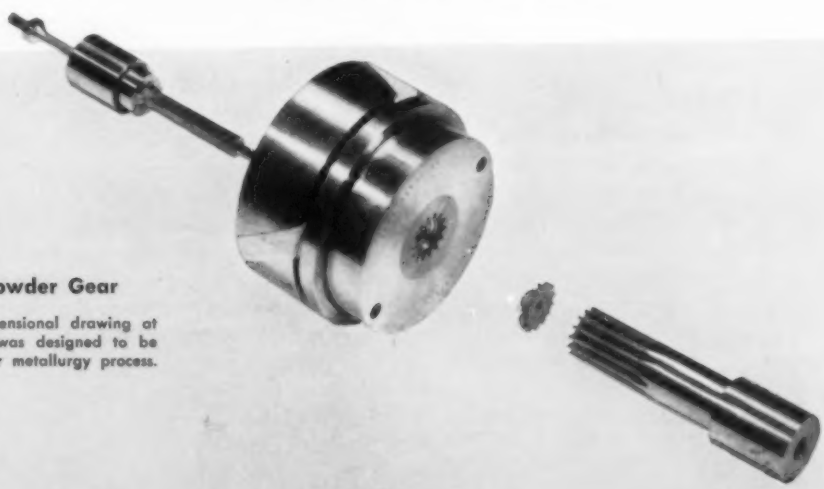
Close control of the relationship between volume of loose powder charged into the die and volume of the compact is also important. This factor is known as the compression ratio, and Fig. 1 shows how it is related to briquetting pressure and density in producing a range of sintered tensile strengths in a particular iron powder mixture.

There is a limit, regardless of the pressure applied, to the densification that can be achieved in a single pressing and sintering. This limit is different for each metal-powder mixture, and it also governs tool capacity.

Because the degree of compaction is controllable, metal-powder parts can be of various densities or porosities. They can be as dense as wrought materials. It is equally possible to produce a structure that is only a latticework, with large voids occurring throughout.

Of course, less-than-full density has limiting effects on most materials. But in metal-powder parts this characteristic should also be regarded as a means of suiting materials and costs more exactly to the actual requirements of a given application.

Of course it is possible to put pressed and sintered



Tools For A Metal Powder Gear

Kitchen utensil gear (see dimensional drawing at right) formed by this tool set was designed to be made specifically by the powder metallurgy process.

parts through additional cycles, to achieve higher density and improve tolerances. But because almost all metal-powder parts being produced today are formed in a single compression and sintering, the following design data have been limited to information applying to such high-volume production practices.

DESIGN SUGGESTIONS FOR SOME BASIC SHAPES

A series of shapes and types of contours, progressively more complicated, have been selected to demonstrate some of the major factors influencing the design of sintered structural parts. These include: a plain solid cylinder, a flanged solid cylinder, a flanged cylinder with one or more holes, and raised or recessed horizontal contours.

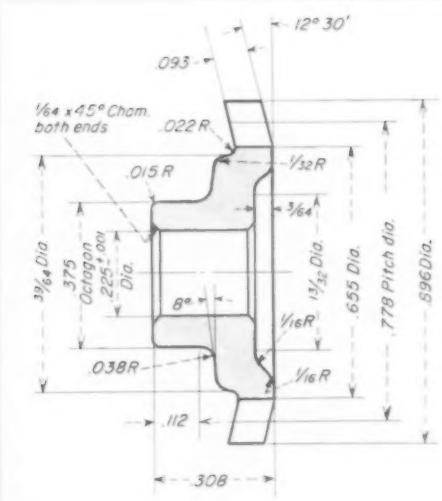
Solid, Cylindrical Parts. Opinions differ on how long metal-powder parts can be, relative to diameter. Further research is needed to clarify this and establish definite values. In general, parts having a diameter-to-length ratio of 1:1 are always easier to produce than parts with 1:2, 1:3 or longer ones. Some authorities state, as a rough rule of thumb, that length should be comparable to cross-section area. Others believe that a 1:3 ratio is maximum.

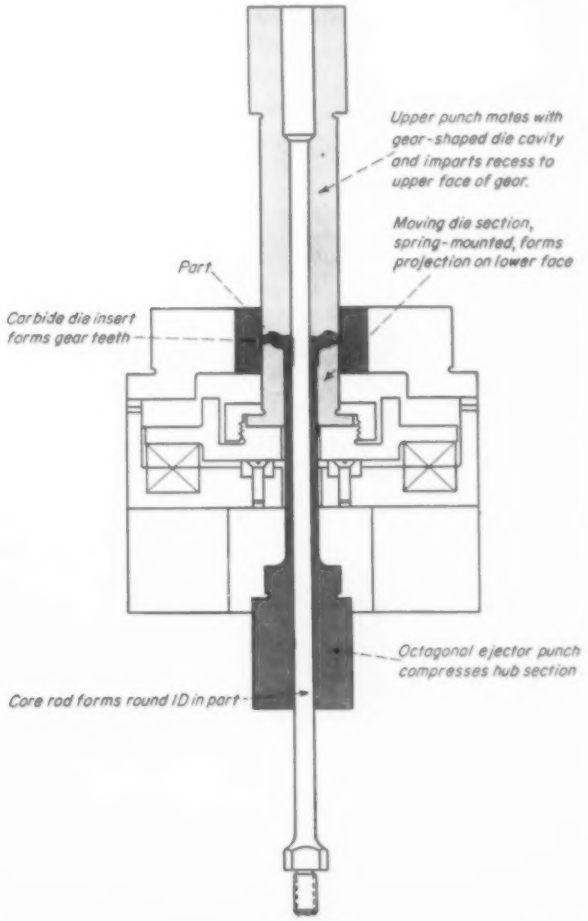
Parts have been made successfully with a ratio as high as 1:7, but this required special material, tool design, press setup and density allowances.

The plain, solid cylinder may also be square, oblong or rectangular in cross-section, or may even have the shape of a gear on its outer diameter. Just about any shape for which tools can be produced is feasible. Of course, such tools must also be capable of transmitting sufficient pressure to all sections of the powder compact.

The size and weight of metal-powder parts is limited only by the equipment available. Parts up to 3 ft in diameter have been produced in a hand-operated hydraulic press. Sintered steel parts up to 10-in. dia, weighing 7 to 8 lb, have been made in one of the largest automatic presses. Parts ½ in. in cross-sectional area, and even smaller, have been produced.

Flanged, Cylindrical Parts. This shape is a combination of the plain, solid cylinder with a flange-shaped radial variation, such as rounds, flats or wings. Straight or curved contours, and helical or other types of gear




Upper punch mates with gear-shaped die cavity and imparts recess to upper face of gear.
Moving die section, spring-mounted, forms projection on lower face
Part
Carbide die insert forms gear teeth
Octagonal ejector punch compresses hub section
Core rod forms round ID in part

The metal powder process eliminates secondary machining operations, and produces this ⅞-in.-dia gear (above), ready for assembly.

Gear has round bore formed by cylindrical core rod; octagonal hole in lower die forms hub OD; octagonal ejector punch compresses hub section. Tool set drawing at right.

Bevel-gear teeth (18 pitch) are formed in a carbide section of die, with pressure applied by mating upper punch.

Recess in upper face of gear is designed to keep density uniform throughout central section of part. Projection on lower face is formed by a spring-mounted moving die section.

METAL-POWDER PARTS

Design details readily produced by metal powder process.
Parts are about twice actual size

Main drive pinion, 3/16 in. thick, for small alarm clock; teeth on hub are 32 pitch. Shoulder on opposite face has tenon to allow staking to wheel in later operation.

Gear reset pinion for small clock is 3/8 in. OD and costs about the same as stamped part, but is more uniform and has no burrs requiring additional operation to remove.

Indexing gear for business machine has D-shaped core hole, and a modified gear flange, 5/8 in. dia. If machined, this form would have to be milled on an indexing head.

shapes can be formed on the flange. Such details are also possible on the shank—or on both sections in the same part.

These design possibilities are not limited to two-level parts. Three or more levels, concentric or non-concentric (as in cams) are possible. Such multi-level parts may present problems in maintaining a suitable range of density in all sections, but relatively simple tool details will generally provide adequate solutions.

When a flanged part is ejected from its die, the lower, or ejecting, punch bears only on the hub or central section. This means that the flange may be unsupported during ejection. However, die friction can cause the flange to break off and remain in the die, because the "green" or unsintered strength is quite low.

Various special tooling components or press setups are available to eliminate breakage, especially where parts with excessive flange overhang must be produced. Some taper, perhaps 1° or so, can also be used on the outside flange diameter to ease ejection. Such special precautions are often not required, because many regularly produced flanges are not wide enough to cause breakage during ejection.

Flanged, Cylindrical Parts with One or More Holes. Cored cylinders, with or without flanges, are typical of one of the oldest applications of metal powder—bushings and bearings. The core pin used to form such holes can be of any shape or radial contour that can be machined into the pin and the mating tool parts. For example, flats, oblongs, gear shapes, fins and splines can all be formed as easily as plain round holes. Tool costs increase, of course.

All these shapes can also be provided in blind or stepped holes. Holes can be tapered either from the bottom up or from the top down.

There is no fixed limit, except those imposed by tooling limitations, on the number of holes that can be produced in a given part. However, such tooling can only operate satisfactorily when alignment and centering between core pins and their mating punch holes are perfect. In some parts tooling difficulties may make it advisable to drill some of the holes after sintering.

Holes should not be less than 0.030 in. in diameter. Holes as small as 0.010 in. have been produced but depths are limited. Die friction can be great enough to break core pins when producing small-diameter holes that are too deep. Hole size and depth limits are also influenced by the type of material being compacted, by core-pin finish and other factors.

The wall surrounding a hole in a sintered part can be as little as 0.030-in. thick. While parts have been produced with wall thicknesses of only 0.025 in., the

Pole piece for shaded pole electric motor was formed vertically by arc-shaped punches. Projections on punch faces produced the recesses. Part is 1 in. long.

Bronze bushing for gas meter is 3/8 in. OD and has a tapered face opposite the blind hole. Radius at closed face was produced at bottom of die. Blind hole is straight-sided and formed by core pin in upper punch. Core pin has cone point, which formed hole. Density at bottom is high but acceptable.

Pallet or timing rocker, 7/16 in. long, used in clock mechanism, required sharp-edged corners, obtained by splitting die sections at these points. Uniformity and smooth finish of sintered part eliminated hand polishing.

Helical drive gear, ½ in. dia, for model locomotive has helical teeth on outside diameter formed by punches rotating during pressure stroke.

Cavity in the die set for this bevel gear for hand drill, 1 in. OD, was formed by hubbing desired gear contours into female die section. Taper between top surface and gear teeth prevents punch from hitting die in closing.

Small clock part has smooth 0.020 in. slot which runs into 0.003 in. radius on both ends.

tooling involved is generally too weak for normal production procedures. In general, a 0.040 to 0.050-in. minimum wall thickness is advisable.

Raised or Recessed Horizontal Contours. A variety of face shapes, or raised or recessed contours, can be imparted to the upper or lower horizontal surfaces of metal-powder parts. Many of the types of details regularly formed in compacting presses as part of the regular pressing operation would be milled or engraved into traditionally produced components.

The maximum height of raised details and the depth of recessed areas is governed by the same general rule applying to sections of various thicknesses in the part as a whole. The difference between the thickest and thinnest portions should be kept small. Too-high raised areas and too-low recesses may cause differences in compression ratios, resulting in non-uniform mechanical properties.

However, when such raised or recessed details must be included in a design, it is possible to compensate for them by incorporating details in the opposite face of the part.

DESIGN DETAILS

In most cases, metal-powder parts can be produced with perfectly straight and parallel sides, unless un-

Timing cam 5/16 in. OD for alarm clock. Face cam and three-step thickness formed in conventional double-action press and tooling. Density varied but was within acceptable limits.

Face of dog clutch for household fan, ⅝ in. OD, has two projections. To maintain desired density in these lugs, recesses in opposite side are formed by projections on upper punch face.

Rotor for toy electric motor, 7/16 in. dia, is an example of extreme die and punch contours, combined with long 0.050 in. hole. Pin could be no smaller and still withstand friction developed in ejection.

Center hub of toy locomotive drive wheel, 15/32 in. OD, has two cores, one eccentric. Deep recesses formed by projections on top punch are rounded to aid in displacement of powder to prevent variation in density. Lower punch is about 1/16 in. smaller diameter than the part itself.

METAL-POWDER PARTS

Fine Surface Detail

(About 1½ times actual size)

Side wheel of truck for model train is 1½ in. long; contours and detail are modeled to scale. Thickest portions (at ends) have blind oblong cored holes to clear ends of truck axles. Oil impregnation provides lubrication.

Markings and face contours on this valve handle were made by recesses in upper punch. Projection on lower punch formed steps on bottom. Stepped core pin produced two-diameter hole. Part is 1¼ in. long.

supported sections of a compact cannot be ejected successfully. Where the shape of a part or the tooling or press will not permit support, a 1 or 2° angle may be required.

Tapers in metal-powder parts may have almost any angle. For vertical tapers, it is advisable to provide straight sections above and below, so that upper and lower tool elements do not meet at the end of the compression stroke. This is a necessity at the top, where the punch would strike the top of the tapered section of the die. The straight section can sometimes be eliminated at the bottom if necessary.

Undercuts, peripheral recesses, lateral holes, threads and other design details involving re-entrant angles cannot be produced in present-day production equipment. Collapsible dies or tool assemblies having laterally sliding parts have usually proved unfeasible, because of the pressures required to produce satisfactory compacts. There is considerable distortion of tooling during the compression cycle, making it difficult to maintain tolerances and clearances between tool components operating in other than up-and-down directions.

Chamfers can be provided at all exterior corners and edges to reduce burrs. Radii are advisable at all right-angle intersections, such as under a flange. Radii should be 0.010 in., min, if possible.

Chamfers may be as great as 45° to the horizontal, and of any reasonable size, so long as they do not exceed this angle. Greater angles are only possible if flats are allowable at the base of the chamfers. This avoids maintaining razor edges on punch faces.

SPECIFICATION OF SINTERED PARTS

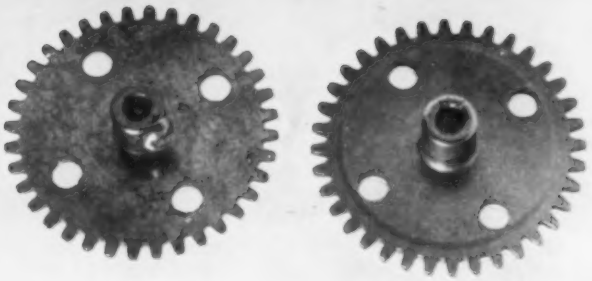
Only infrequent spot inspection of parts is required, once a given run has been set up and is proceeding satisfactorily through pressing and sintering equipment. This uniformity is largely because of the widespread use of carbide dies, which provide a life of millions of pressings.

Tolerances of 0.0015 in. per in. on radial dimensions (perpendicular to direction of compression) are typical of those maintained through a single pressing and sintering. Axial dimensions are commonly held to 0.0025 in. per in. If required, even closer tolerances are possible, particularly if a coining step is included.

Difficulties may develop when applying standard methods of testing to metal-powder parts, because of their basically different characteristics. For example, the indenters used in many hardness tests generally

Face-serrated part (13/16 in. OD) right, adjusts elevation of fan. Recess in opposite face mates with tubular cradle of fan. Steel was required for hardness and wear resistance.

Cam and gear, 1 13/16 in. OD, left, combined for calendar clock. Any other process would have required two separate and expensive parts, with a difficult assembly operation. High hardness was required for wear resistance.



Drive gear (1 9/16 in. OD) for toy construction set was originally a staked assembly of a brass-plated steel stamping and a machined hub. Hub is drilled and tapped, as before, to take a set screw. Note multiple holes in wide thin flange. Separate punch under flange section helped in ejection.

enter the pores in metal-powder parts. This in effect measures porosity along with, or instead of, hardness. Magnetic-particle detection of cracks is difficult because of this same porosity. X-ray inspection has little value, because blowholes, gas pockets and similar defects are not encountered.

To obtain desired characteristics and properties, density as well as sintered composition is frequently specified. Some users require actual performance tests, usually accelerated, of sample parts. Some of the parts passing these tests are then used to determine required density, hardness and crush strength.

The ASTM, SAE and the Metal Powder Assn. have issued a listing of standards, specifications and other data on metal powders and metal-powder products. These standards are available, as Data Sheet No. 4, from the Metal Powder Assn, 130 W. 42 St., New York, N. Y.

THE POWDER METALLURGY PROCESS

Basic steps in producing metal-powder parts are:

(1) Mixing metal powders (100 mesh or finer) and additives in equipment similar to tumbling barrels.

(2) Cold-pressing powder mixture in forming tools in almost entirely automatic presses. Production rates of 500 to 3000 pieces an hour are common.

Typical parts redesigned as sintered compacts

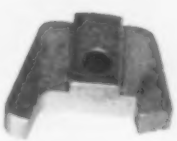
(About 1½ times actual size)

Center pinion for alarm clock, below, formerly made by inserting and staking steel pins in a machined brass hub. Sintered steel part, left, 7/16 in. OD, costs less and avoids loose or missing pins. Oil impregnation improved wear resistance.

Ratchet for alarm clock, below, as a metal powder part (right) costs somewhat more than the stamping, left, but is more uniform and sharper; deeper teeth improved performance. Hub is longer than would be possible if stamped and provides better alignment. Small pad on other side spaces ratchet edges away from mounting plate.

Parts designed "from scratch" for powder metallurgy

(About twice actual size)



Escapement pallet, above, for alarm clock bell has projection keying into recess in stamping to which it is staked. Projection extends to edges of shape to aid in venting air trapped in recess in upper punch during compacting.

Drive hub, left, 1 in. dia. for stove timer required sharp corner between tooth and flange. Steel provides wear resistance. Tooling was relatively inexpensive; shape would be impossible to machine.

(3) Sintering compacts in continuous furnaces up to 2100 F, using protective atmospheres such as dissociated ammonia, hydrogen, various special gases.

(4) Sizing or coining (especially for brass and bronze parts) in tools approximately same size and shape as original pressing tools to impart good finish, assure close tolerances, increase density. All parts that have been through a single pressing and sintering can be further compressed. Distortion caused by sintering can also be corrected. Most metal powder parts do not require sizing—all bearings do.

Typical setup time on a metal powder press is 1 hr. Longer times are sometimes required.

Sintered parts can be machined according to standard practice. Hardening, plating and other finishing processes are also applicable. All single-pressed and sintered parts have inherent, interconnected porosity. Most liquid baths should be avoided, because detrimental ingredients such as hardening salts and cleaning compounds will be difficult to remove. Special techniques are required.

Typical cycle of a metal-powder press begins with the lower punch level with the die table after it has completed its ejection stroke. It remains level while the powder-feeding shoe swings into position, pushing the compact aside. This shoe contains the feed hole through which metal powder is fed into the die for the next compact.

The powder does not simply flow into the cavity as the lower punch retracts. Rather, the lower punch tends to suck the powder down into the cavity.

With the shoe backed away again from the cavity, the upper punch enters the die to compress the powder against the resistance of the lower punch. Pressure can also be exerted upwards by this bottom punch. Again the lower punch begins the ejection stroke, finishing when it is again level with the die table and the new compact is pushed aside by the returning shoe.

MANUFACTURE, COST AND USE OF TOOLS

Practically all tooling for metal-powder pressing is designed with a single cavity—for pressing one compact at a time. Two or more parts have been made with each cycle of the press, but this so complicates tooling and press operation that the added production seldom pays for the added costs.

A set of tools—punches, dies and other parts—to make plain cylindrical parts in a small press may cost as little as $150. As much as $5000 to $10,000 may be required for extremely complicated, large equipment. Normally, however, a set of tools for the most frequently produced types of compacts will be under $1000, with the bulk of the simpler ones costing less than $500.

Where 25,000 higher-density parts may be produced with steel tools, more than 1 million can be expected from tungsten carbide dies and core pins.

Tool life is generally longer than for any other manufacturing process, and costs frequently lower. For example, initial tooling costs are usually less than for die casting or plastic molding. While tooling for screw machines is less, many other machined parts require higher over-all tool costs, because they generally must go through multiple operations, each with its own tooling charges.

IS POWDER METALLURGY GOOD ONLY FOR LONG-RUN JOBS?

A recent application of powder metallurgy involved substitution of a pressed and sintered latch part for a unit that formerly was stamped. Although only 500 to 700 of these parts were required a year, it proved cheaper to make them of metal powder. The one set of tools required for the single powder-pressing operation was less expensive than those required for the original blanking-press operation. In addition, hand operations were eliminated, better properties obtained, inspection costs reduced and more useful contours (including a sharp edge) were provided.

Normally, the powder-metallurgy process cannot successfully compete with stamping costs. However, the case described indicates that determining relative costs and deciding when metal-powder techniques will fit in with short-run production can only be done by analyzing each situation as it arises in everyday practice.

Successful short-run production generally requires: 1) parts designed for the powder-metallurgy process itself (rather than carrying over same contours and elements from original component); 2) simple, flexible tooling; 3) standardization of parts, particularly bearings; 4) strict process control.

BACKGROUND READING

A number of earlier articles have included data on adapting design to the specific requirements of sintered powdered parts. Recent ones are:

"Submicron Metal Powders" June 1957 page 182; finer particle sizes make sintered parts as strong and dense as solid metal.

"Powder Metal Process and Part Design" Design Digest, Mid-October 1955 page D14; influence of shape, size, tolerances and mechanical properties on selection of metal powder process.

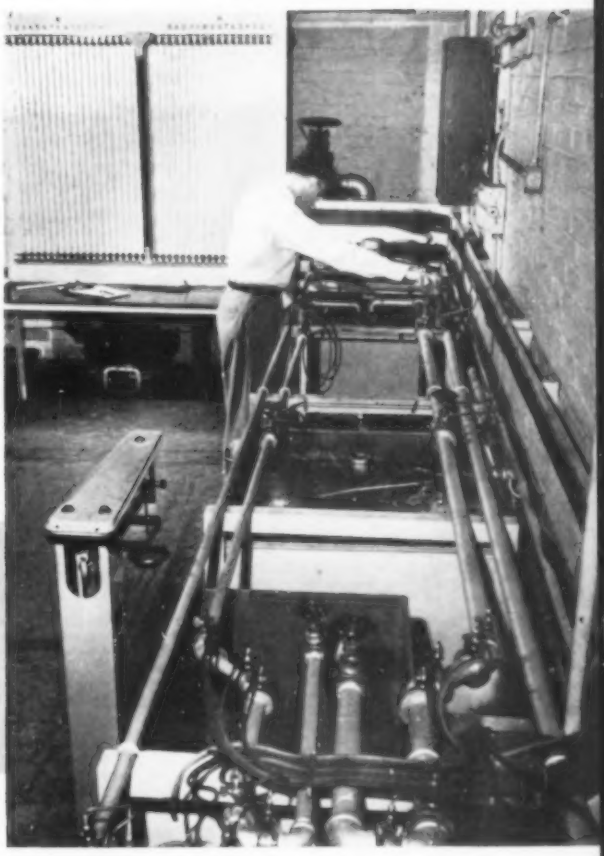
"High-Strength Alloy-Steel Powder-Metal Parts" March 1955 page 133; hardenable alloy parts with strength, hardness and wear approaching solid metal.

"Powder-Metal Bronze Bearings" April 1954 page 182; press fits, load capacity, ID close-in, running clearances, bearing chamfers and other design data for self-lubricating bearings.

"Powdered Metals—New Uses May Surprise You" Design Digest, Mid-October 1953 page B28. Summary of significant developments affecting design of parts.

Acknowledgement—Design data, case histories and samples helpful in preparing this article were contributed by: American Meter Co., Parker-White Metal Co., Burgess-Norton Mfg. Co., Pitney-Bowes, Inc., A. C. Gilbert Co., Lux Clock Co., Whitney Chain Co., John Rigby & Sons Ltd.

Pipe friction . . .
calculations are checked experimentally at Newark College of Engineering. Loss factors for various valve styles are determined by connecting pressure taps to appropriate manometer.



FRICTION in Pipes – a wide-range nomograph

Calculation of friction-pressure drop in pipes is drudgery to those who do it frequently, and the occasional calculator may have trouble getting started. This nomograph will help both groups because it covers viscous and turbulent flow in an easy-to-follow manner.

REAGAN HOUSTON, *Senior Engineer*
Linde Company, Tonawanda, N. Y.

Rapid and accurate estimation of friction-pressure drop in straight circular pipes is an important first step in many designs such as hydraulic-actuating systems for aircraft and machine tools, forced-flow heat exchangers, refrigerator circuits, and automotive exhaust piping. In the many existing methods, simplifying assumptions are often made which leave the user asking: "Does this chart apply to my problems?"

This nomograph has been developed from the basic Fanning equation without these simplifying assumptions. Accuracy is that of the Fanning equation itself. For very low pressures, molecular flow may occur and the Fanning equation is inapplicable. Here, the pressure in microns of mercury times the pipe diameter in inches should be greater than 220.

Using conventional nomenclature (see box), the Fanning equation for circular pipes is

$$\frac{dF}{dL} = \frac{4fV^2}{2gD}$$

Usually, the flow rate W is more convenient to use than the velocity. Converting

$$\frac{dF}{dL} = \frac{32fW^2}{\pi^2 g \rho^2 D^5}$$

Where fluid density ρ is constant, as in isothermal liquid flow, and where the friction factor f is constant, the equation can be integrated to

$$\frac{F}{L} = \frac{32fW^2}{\pi^2 g \rho^2 D^5}$$

In practice, pipe diameter is commonly in inches d

rather than feet D, and the pressure drop is wanted in psi. Making the appropriate conversions and consolidating constants

$$\frac{\Delta P}{L} = \frac{13.44 f W^2}{10^6 \rho d^5}$$

The friction factor f depends primarily on the Reynolds number which can be written in two useful forms:

$$N_R = \frac{\rho V D}{\mu'} = \frac{6.32 W}{\mu d}$$

Here, viscosity μ' in lb/hr-ft is 2.42 times viscosity μ in centipoises. No single simple equation gives the relation between friction factor and Reynolds number in both the streamline and turbulent regions. Consequently, the standard graphical relation is made part of the nomograph.

For simplicity, several scales have been combined; however, the assembly of so many steps into one nomograph requires special aids for the user. For example, the arrows on the operation lines for the sample problem show the normal direction of calculation, and the circled symbols show which scales to use. Working in this "normal" direction, the proper scale on any doubled scale is on the approach side. The symbol T means turn at the outside line.

Viscosity is the least common property required, and Table I gives a few values for common fluids for rough pressure-drop calculations on unfamiliar, but similar, fluids. In the streamline flow region, however, pressure drop varies directly with viscosity, and accurate viscosity data are necessary.

The friction factor is generally accurate within $\pm 10\%$ for pipe and $\pm 5\%$ for smooth tubing in the turbulent region. For both gases and liquids, the average values of density and viscosity should be used for the section of pipe under consideration. If either vary more than 15%, a stepwise integration over the pipe length may be warranted.

The Fanning equation is an empirical relation covering wall friction drop only, and losses from fittings, bends and constrictions must be taken into account elsewhere. Friction drop in fittings and valves is calculated by multiplying the velocity head at the obstruction by an appropriate K-factor, determined experimentally with apparatus similar to that shown on the first page.

TABLE 1—Typical Viscosities in Centipoises at 68 F

Hydrogen, 1 atm	0.009
Methane	0.012
Air	0.018
Water	1.0
Kerosene	2.5
Sulfuric acid, 60%	7.0
Linseed oil, raw	45.0

NOMENCLATURE

- D = Inside diameter, ft
- d = Inside diameter, in.
- f = Friction factor, dimensionless
- F = Friction, ft-lb/lb
- L = Length of pipe, ft
- P = Pressure, psi
- V = Velocity (average), ft/hr
- W = Mass rate of flow, lb/hr
- μ = Viscosity, centipoises
- μ' = Viscosity, lb/hr-ft
- ρ = Density, lb/cu ft
- N_R = Reynolds number, dimensionless
- g = Gravitational acceleration, ft/hr^2

EXAMPLE:

A liquid of 60 lb/cu ft density and 0.4-centipoise viscosity flows through a 2-in. ID tube at the rate of 50,000 lb/hr. What is the friction pressure drop per foot of length?

Begin at the upper left-hand chart at $W = 50{,}000$. Proceed through $D = 2$ in. to a turning point on line x, then through μ of 0.4 to the Reynolds number of 395,000. Go vertically to the line marked "tubes", then horizontally to a friction factor of 0.0035. From this friction factor, proceed through $\rho = 60$ to a turning point on line y back through $W = 50{,}000$ to line z and finally through $D = 2$ to $\Delta P/L$ of 0.061 psi per ft.

EDITOR'S NOTE: Other recent articles concerned with fluid flow analysis include:

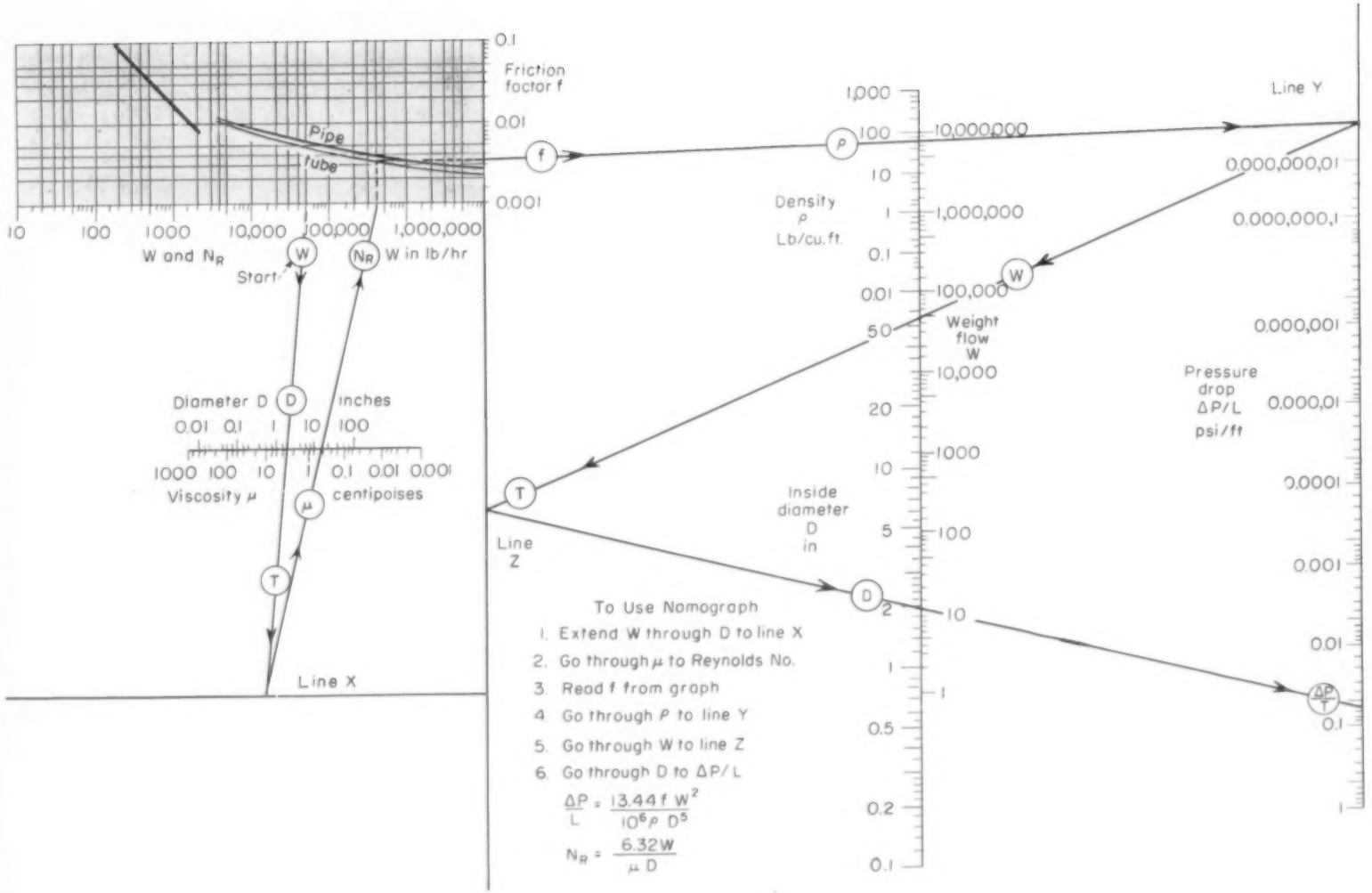
"Nomograph for Designing Gas Nozzles and Orifices" October 1956 page 141. Chart gives weight rate of flow if pressure ratio, upstream pressure and orifice diameter are known.

"Pressure Losses in Flexible Metal Tubing" April 1956 page 223. Friction coefficients and pressure loss data for corrugated flexible hose of annular and helical type at high flow rates.

"Theory of Hydraulic Flow Control" April 1955 page 161. Comprehensive presentation of methods for calculating hydraulic resistance in parallel and series piping circuits, valves, ventures, orifices and other flow-limiting devices.

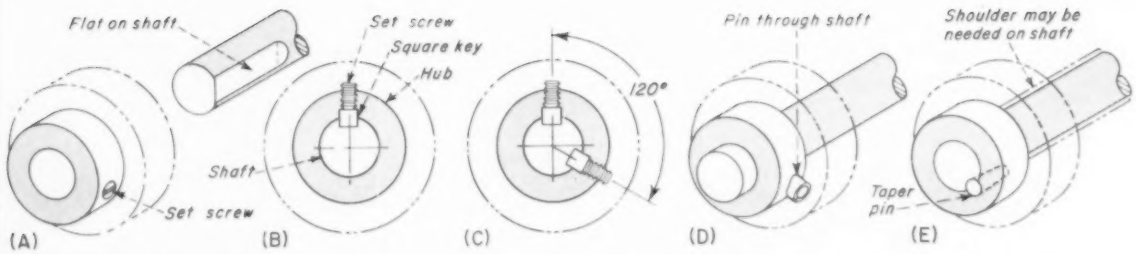
"Visual Flow Analysis" August 1955 page 154. Summary of simple and inexpensive empirical methods for studying and recording fluid flow around solid objects and through constrictions in piping.

"Reynolds Number Chart" April 1955 page 213. Nomograph for computation of Reynolds number for liquid flow in pipes ½ to 120 in. in diameter.


Friction factor f
0.1
0.01
0.001
Pipe
Tube
10
100
1000
10,000
100,000
1,000,000
W and N_R
Start
W
N_R
W in lb/hr
Diameter D
inches
0.01 0.1 1 10 100
1000 100 10 1 0.1 0.01 0.001
Viscosity μ
centipoises
μ
T
Line X
Line Y
Line Z
ρ
Density ρ Lb/cu.ft.
1,000
100
10
1
0.1
0.01
0.001
10,000,000
1,000,000
100,000
10,000
1000
100
10
1
0.1
Weight flow W
50
20
10
5
2
1
0.5
0.2
0.1
Inside diameter D in
D
Pressure drop ΔP/L psi/ft
0.000,000,01
0.000,000,1
0.000,001
0.000,01
0.0001
0.001
0.01
0.1
1
ΔP/T
To Use Nomograph
1. Extend W through D to line X
2. Go through μ to Reynolds No.
3. Read f from graph
4. Go through P to line Y
5. Go through W to line Z
6. Go through D to ΔP/L
$\frac{\Delta P}{L} = \frac{13.44 f W^2}{10^6 \rho D^5}$
$N_R = \frac{6.32W}{\mu D}$

M. LEVINE *Grant Pulley and Hardware Corp.*

14 WAYS TO FASTEN HUBS



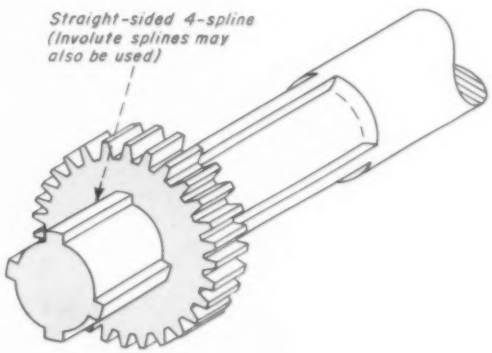
1 Cup-point setscrew . . .

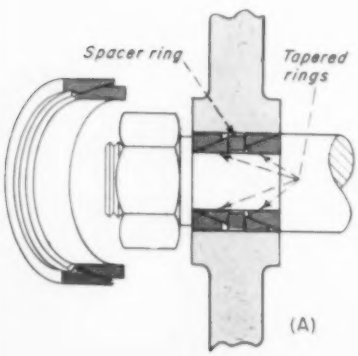
in hub (A) bears against flat on shaft. Fastening suitable for fractional horsepower drives with low shock loads. Unsuitable when frequent removal and assembly necessary. Key with setscrew (B) prevents shaft marring from frequent removal and assembly. Not suitable where high concentricity is required.

Can withstand high shock loads. Two keys 120° apart (C) transmit extra heavy loads. Straight or tapered pin (D) prevents end play. For experimental setups expanding pin is positive yet easy to remove. Gear-pinning machines are available. Taper pin (E) parallel to shaft may require shoulder on shaft. Can be used when gear or pulley has no hub.

4 Splined shafts . . .

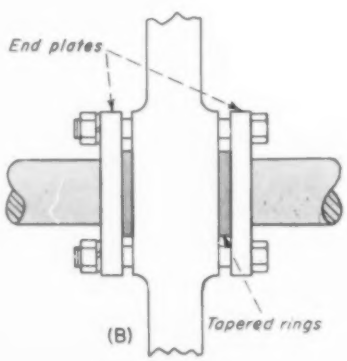
are frequently used when gear must slide. Square splines can be ground to close minor diameter fits but involute splines are self-centering and stronger. Non-sliding gears may be pinned to shaft if provided with hub.





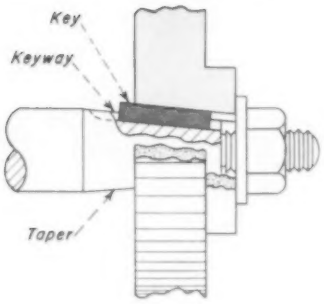
7 Interlocking . . .

tapered rings hold hub tightly to shaft when nut is tightened. Coarse tolerance machining of hub and shaft does not effect concentricity as in pinned and keyed assemblies. Shoulder is required (A) for end-of-shaft mounting; end plates and four bolts (B) allow hub to be mounted anywhere on shaft.



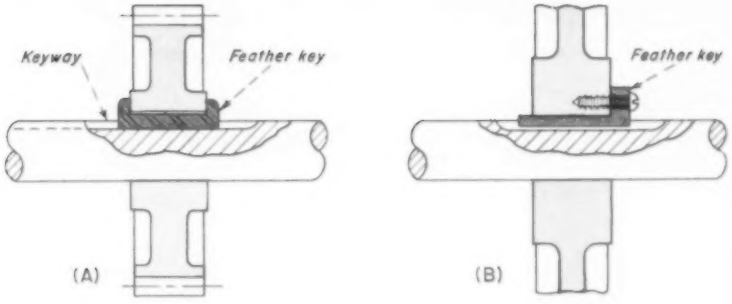
TO SHAFTS

DESIGN ROUNDUP...



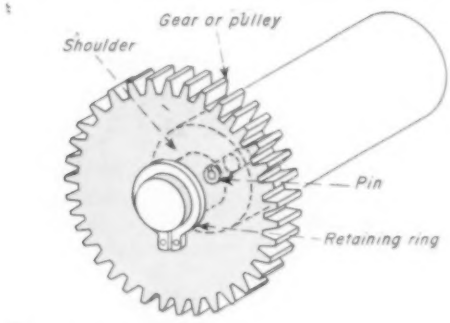
2 Tapered shaft . . .

with key and threaded end provides rigid, concentric assembly. Suitable for heavy-duty applications, yet can be easily dissasembled.



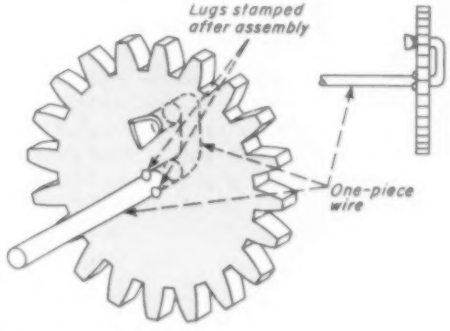
3 Feather key . . .

(A) allows axial movement. Keyway must be milled to end of shaft. For blind keyway (B) hub and key must be drilled and tapped, but design allows gear to be mounted anywhere on shaft with only a short keyway.



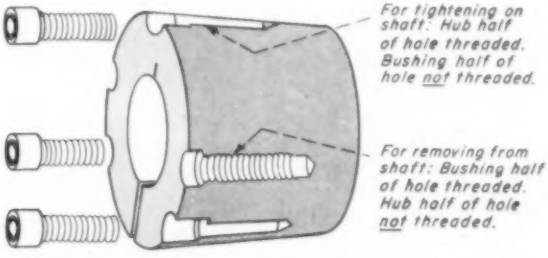
5 Retaining ring . . .

allows quick removal in light load applications. Shoulder on shaft necessary. Pin securing gear to shaft can be shear-pin if protection against excessive load required.



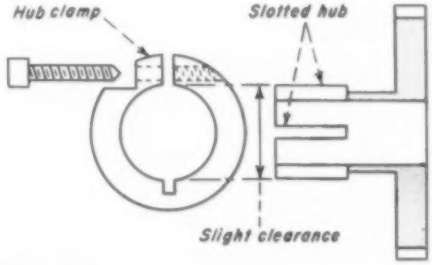
6 Stamped gear . . .

and formed wire shaft used mostly in toys. Lugs stamped on both legs of wire to prevent disassembly. Bend radii of shaft should be small enough to allow gear to seat.


For tightening on shaft: Hub half of hole threaded. Bushing half of hole not threaded.
For removing from shaft: Bushing half of hole threaded. Hub half of hole not threaded.

8 Split bushing . . .

has tapered outer diameter. Split holes in bushing align with split holes in hub. For tightening, hub half of hole is tapped, bushing half is un-tapped. Screw therefore pulls bushing into hub as screw is screwed into hub. Bushing is jacked from hub by a reverse procedure. Sizes of bushings avaliable for 1/2- to 10-in. dia shafts. Adapters are available for untapered hubs.



9 Split hub . . .

of stock precision gear is clamped onto shaft with separate hub clamp. Manufacturers list correctly dimensioned hubs and clamps so that efficient fastening can be made based on precision ground shaft. Ideal for experimental set-ups.

SWITCHING-LOGIC FUNCTIONS

simplify application of static control devices for machine controls . . .

JACK SHEETS, *Mgr., Panel Production Engineering*
and
RUSSELL A. BROWN, *Application Engineer*
General Purpose Control Dept., General Electric Company
Bloomington, Illinois

Reliability and life of machine control systems are improved by static control systems using magnetic-core elements. These systems are an interconnected combination of pilot devices, logic elements, and power amplifiers.

The pilot devices usually are standard pushbuttons and limit switches such as described in "Pilot Control Devices," May 1955 page 187. Logic elements make the control-circuit decisions to provide the proper signals and signal paths called for by the various machine operating sequences initiated by operation of the pilot devices. These logic elements may be static devices or relays; with static devices the power output is usually not sufficient to directly drive solenoid valves, motors, clutches or other actuating devices and power amplifiers are required.

Logic Functions

Although logic elements are associated currently with static control systems, they have long been used in the design of telephone relay circuits and computers. Logic elements are combinations of input and output electrical control signals. For example, a control signal applied to a relay causes the relay contacts to close and produce an output, which may control other relays which supply signals to other portions of the control circuit.

Control signal voltages for standard machine-tool relays are usually 115 a-c. A static control system obtains its operating power from a 115-v a-c line, but performs the decision-making functions in the logic elements at a substantially lower a-c or d-c voltage level, with an output of a fractional watt.

Five basic logic functions are shown in Fig. 1. The *AND* function is a control element which has one or more inputs, all of which must be present before an output signal may be obtained, as shown at (A). This is identical in function to a conventional control-relay circuit in which the contacts *A*, *B*, *C*, and *D* must be closed before the coil of relay *CR-E* can be energized. When this occurs, relay *E* produces an output by energizing some other control circuit or circuits.

The *OR* logic function produces an output when one of two or more inputs is present. Here, either *A* or *B* produces the output *E*.

The *NOT* logic function produces an output when an input signal is not present. For example, when relay *A*, which has a normally-closed contact is not energized, relay *CR-B* is energized, producing an output.

The *MEMORY* function provides an output until such time as a stop signal is applied. Either a momentary or continuous signal turns it off. Thus, the *MEMORY* element remembers which of the two signals, ON or OFF, was last applied. This function is similar to a latched relay in which a mechanical latch holds the armature in the energized position until the reset coil is energized.

A second type of *MEMORY*, which also can be obtained with relays has a sealing-interlock circuit, the type most commonly used in motor starter circuits. Here, an interlock seals a momentary START button

(CONTINUED ON PAGE 198)

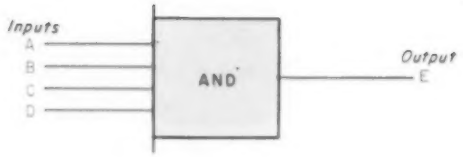
1 Comparison of . . . ▶

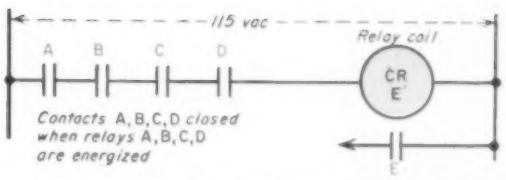
logic functions and their equivalent relay circuits. The inputs represent electrical control signals while the output is a new signal. For the AND, OR, and NOT functions the number of inputs is not limited to those shown here. When the output of an AND is applied back to the input this circuit provides a type of MEMORY function, and is called a SEALED-AND MEMORY. There is, however, a distinction between this and the other two types shown. The PERMANENT MEMORY provides a function which remains in the ON or OFF state even though power is removed from the unit. When the power is reapplied, it comes back on in whatever condition it was when deenergized. The RELEASE MEMORY is a function which has to have an input to turn it ON and an input to turn it OFF; it corresponds to a relay with two coils and a mechanical latch which holds in the energized condition. To return the relay to OFF, the drop-out coil must be energized.

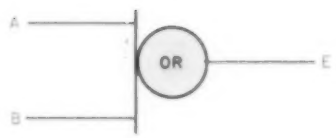
The SEALED-AND MEMORY, although it produces an output once an input has been applied, will return to the OFF condition once power is interrupted. In this respect it is a useful fail-safe device.

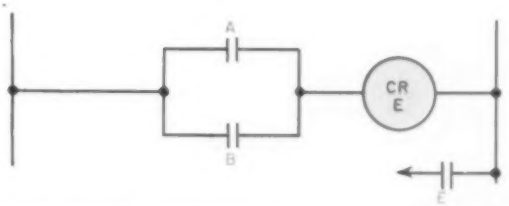
LOGIC FUNCTIONS

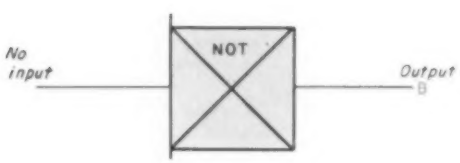
EQUIVALENT RELAY CIRCUITS

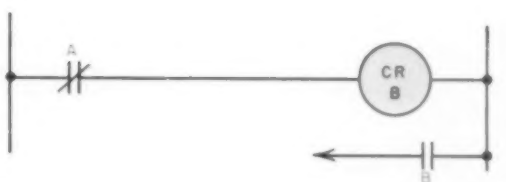


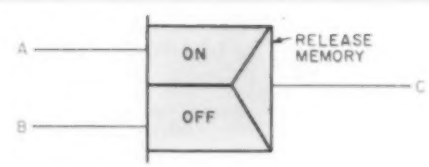


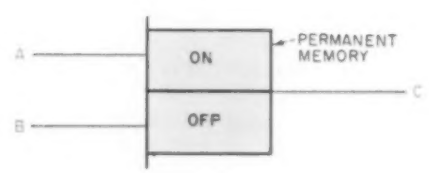


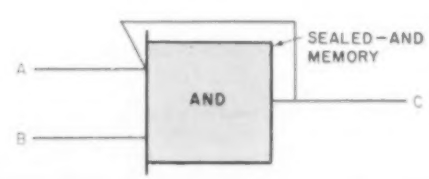


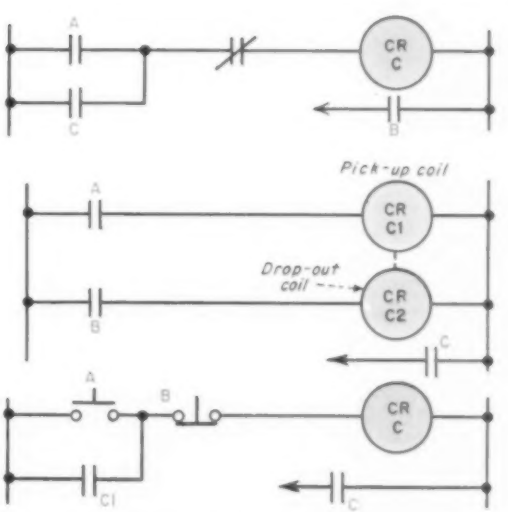


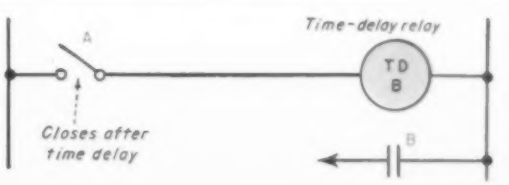












and the starter remains energized until the STOP button is pressed.

A third type of memory function for fail-safe operations on power removal is an AND element with the output connected back to one of the inputs. This provides a sealed circuit that opens when power is interrupted, it is called a SEALED-AND MEMORY.

The fifth type of logic function, *TIME DELAY*, is used to cause an operation at a specific time delay after the input is energized. The output persists until the input signal is removed.

Applying Logic Functions

Use of logic functions simplifies the development, analysis and design of machine control circuits, because this approach identifies the functions of machine-drive and machine-cycle elements with the control signals.

First step in the application of static control to a new or an existing control circuit is setting up an operation sequence. This analysis includes the energizing and deenergizing conditions for driving components, the operating conditions and available circuits of the pilot devices and other information necessary to operation of the machine. A complete statement of this information simplifies selection of the controlling elements and their combination.

DEVELOPING THE SYSTEM

Application of logic functions to the control of a hydraulic riveting machine is shown in Fig. 2. First, the machine cycle is described. Then, the machine-driving functions and the pilot-device descriptions are added. Finally, the information is converted into logic functions and the control circuit. Fig. 3.

Machine Cycle

The machine consists of two hydraulic rams, one to clamp work and one to rivet. To begin a machine cycle, the clamp platen and the rivet ram must be at top position. The *AUTO-INCH* selector is turned to *AUTO* to set up the control circuit for a semiautomatic pressing cycle. In addition, the hydraulic pumps must be in operation. The machine is then ready for a work cycle.

The operator inserts the workpiece in a nest in the machine bed and presses two momentary-contact *DOWN* pushbuttons. This energizes the *Down* solenoids of both rams which start downward at their rated speeds. During the downstroke, an adjustable cam on the clamp platen actuates *DWELL* limit-switch *LS-1*, which may be a momentary or maintained-contact switch.

LS-1 denergizes the rivet ram and initiates time-delay *TD-1* sufficient to allow the clamp platen to contact the work. When this delay expires, the rivet ram resumes its downward travel. The clamp ram meanwhile has built up clamping pressure. The rivet ram then makes contact with the work and presses the rivets into place.

Expiration of the first time delay also initiated time

Sequence Analysis of Machine Cycle and Driving-Device and Pilot-Device Functions

DRIVING-DEVICE FUNCTIONS, SEMIAUTOMATIC OPERATION

Down-Rivet solenoid:
1. Energized by DOWN pushbuttons
2. Deenergized by limit-switch LS-1
3. Reenergized after TIME DELAY
4. Deenergized after dwell time

UP CLAMP STOP limit-switch LS-2: Momentary type, one open and one closed circuit. Operates as clamp ram starts down, operated again when ram is retracted

UP RIVET STOP limit-switch LS-3: Same as LS-2

Down-Clamp solenoid:
1. Energized by DOWN pushbuttons
2. Deenergized after dwell time

Up-Rivet solenoid:
1. Energized by dwell time or UP pushbuttons
2. Deenergized by Rivet Up limit switch LS-3

Up-Clamp solenoid:
1. Energized by dwell time of UP pushbuttons
2. Deenergized by clamp up limit switch LS-2

NOTE: Up and Down solenoids cannot be simultaneously energized in either the INCH or AUTO position. All solenoids are in the INCH position with the AUTO source disconnected, and are energized by individual pushbuttons.

PILOT-DEVICE DESCRIPTIONS

DOWN pushbutton: Momentary-contact type, one open and one closed circuit.

INCH buttons: Momentary type, one open and one closed circuit each.

DWELL limit switch LS-1: Momentary type but stop can be set to operate also as maintained contact; one open, one closed circuit. Actuated by down-stroke of clamp ram; released by up-stroke.

delay 2 which allows the rivet ram to build up to the required riveting tonnage.

Expiration of the second time delay deenergizes the *Down* solenoids and energizes the *Up* solenoids of both rams, which move upward at fixed speeds until the top limit switches are operated, stopping travel of both rams. The cycle is then complete.

Control Circuit Analysis

From this machine-cycle description and other data, driving device functions and pilot device characteristics are listed as in the table.

The machine requires the presence of an operator to initiate each cycle. No special types of equipment are involved in the operation of the press. Solenoids have a spring return to neutral.

Down-Rivet solenoid needs two signals to energize it and thus requires an OR function. Signals from both the DOWN pushbuttons and the DWELL limit switch LS-1 are momentary, indicating the need for a MEMORY function. Either the signal-applied or signal-removed type will work but stopping an operation is safer when a signal is interrupted. For this reason the *SEALED* AND is used.

UP-RIVET limit switch LS-3 opens as the clamp and rivet rams start downward, thus cutting off the pushbutton signal. But the AND element (1) has already delivered an output which seals itself around the pushbutton signal. This output remains until LS-1 reopens. At this time, the *Down-Rivet* solenoid will be deenergized.

This operation of LS-1 also initiates a time delay. A *TIME DELAY* element requires a continued signal, but the operating signal is only momentary, so it is again necessary to use a *MEMORY* function. Either variety of *RELEASE* type may be used, but the DOWN solenoids are deenergized at the end of the timing interval, requiring selection of a *RELEASE MEMORY*.

The normally open contact of LS-1 is used to energize *RELEASE MEMORY* (2) which in turn applies a signal to *TIME DELAY* element (3). The two operating signals for the *Down* solenoid are from the pushbutton and the *DELAY* signal initiated by *LS-1*. The two signals are fed to OR element (4).

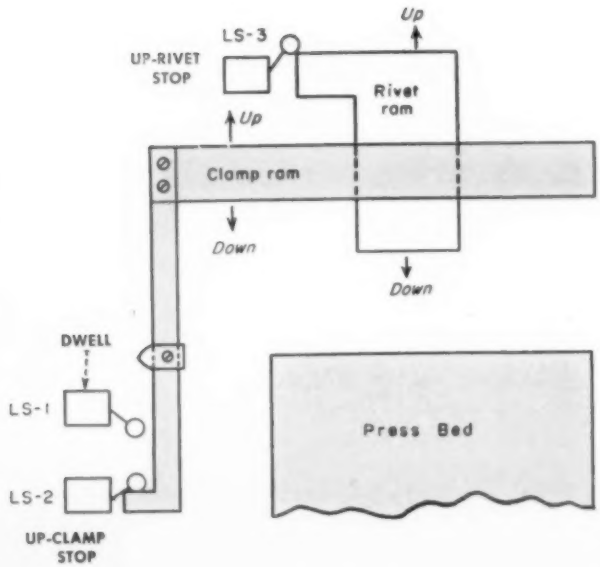
The solenoid is deenergized following the dwell time. This signal is from a DELAY element and indicates the dwell time has *not* expired; this controls the signal for the operation of the DOWN solenoid, since the time delay, when expiring, must deenergize the solenoid.

The signal from the NOT element (5) and the signal from the OR element (4) are fed to another AND element (6); the output of this element drives the amplifier which in turn drives the *Down-Rivet* solenoid.

Because the time delay initiated by LS-1, upon expiring, initiates a second delay interval, TIME DELAY (7) is inserted in the circuit and completes the operation of the *Down-Rivet* solenoid of the rivet ram.

Down-Clamp solenoid is energized by the *Down* pushbuttons and deenergized by the dwell timer, which uses *RELEASE MEMORY* (8); this is turned ON by the closure of the pushbuttons and is turned OFF by the expiration of the dwell time delay.

Up-Rivet and Up-Clamp solenoids are both energized by the expiration of the *DELAY* dwell time. Use of sealed AND functions, (9) and (10), with one signal from the normally closed contact of *Up-Clamp* limit



2 Elementary sketch . . .
of a hydraulic riveting press with operating functions and pilot devices.

switch *LS-2* and the other momentary signal of the dwell-time *DELAY* controls both *Up* solenoids.

Manual Control

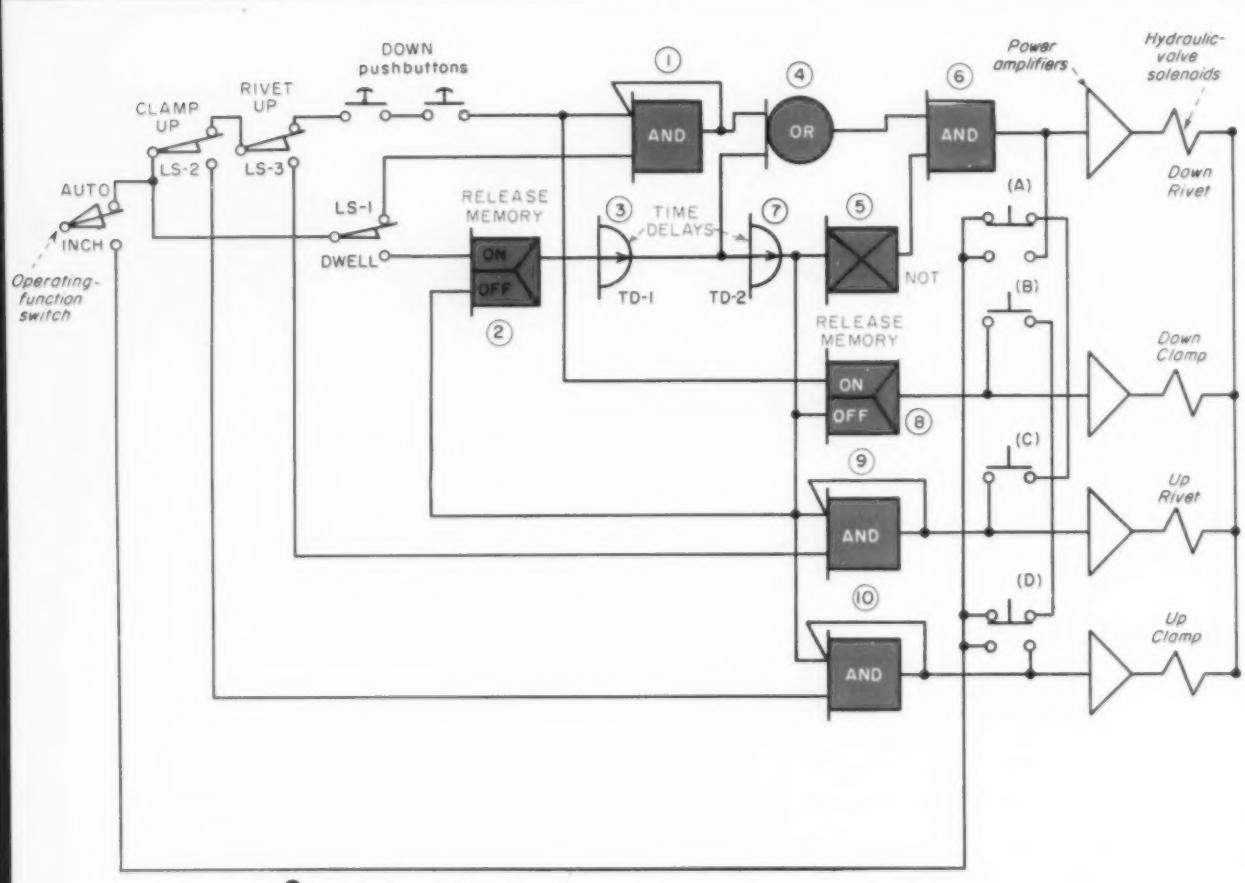
Should the rams fail to retract for any reason, the operator may energize the *UP* solenoids directly by pressing *Up* pushbuttons (*C*) and (*D*), which deenergize the *Down* solenoids and energize the *Up* solenoids.

Controlled, slow movement of the rams needed in setting up dies is obtained by turning the operation selector to INCH and operating the individual solenoids by their buttons.

Making just such a machine sequence analysis as has been described here may entail rewriting the machine specifications in order to arrive at the basic machine functions. The machine may be described in hydraulic, pneumatic, or electrical terms. It will be necessary to weed out intermediate explanations to arrive at the machine cycle and functions of the driving components, such as solenoids, valves, and the like. The machine cycle focuses attention upon the operation sequence of overall control. The driving device functions simplify the selection of controlling elements and the unique combination which will perform the required operations. Most applications will be substantially more complex than the one discussed here, but the principles involved remain the same.

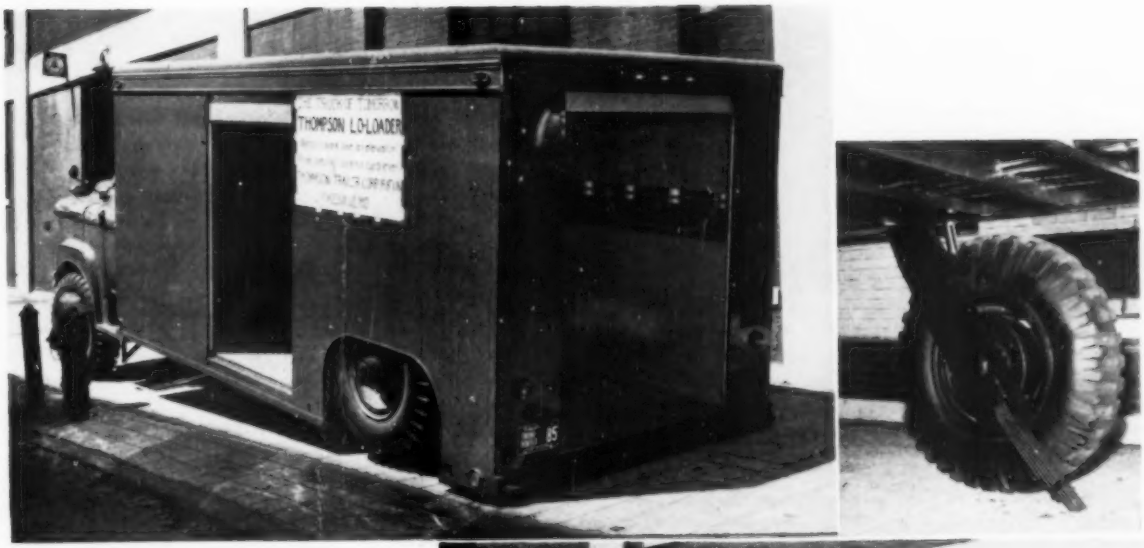
EDITOR'S NOTE: A fundamental aid in analyzing and simplifying complex logic circuits is switching algebra. "Simplifying Relay Control Circuits" November 1956 page 162, explains the use of switching algebra and the meaning of the symbols employed in the logic equations. In the same issue, page 164, an original method for the simplification of relay or control networks is presented.

For standard pushbuttons, master switches, limit switches, and other types see "Pilot Control Devices" May 1955 page 187, for use in manual or automatic control of motors or other power units, and for protection of machines and safety of operating personnel.



3 Logic function diagram . . .
for the control system of the riveting press based on the machine cycle analysis given in the table.

TECHNICAL NEWS



At its fully extended position (top), the Lo-Loader is 52 in. from the ground. It can be lowered flush with the ground, but photo right shows another position which the truck body may assume. A side tip also is possible by lowering one side to the ground, and raising the opposite side to any height. Inset shows wheel arrangement with steel arm and half spring, and hydraulic piston rod. Pivot point of the arm can be seen in top photo. Hydraulic controls are shown at far right in lower photo.

Elevator Truck Van Reduces Load-Unload Time

By eliminating the rear axle and drive shaft, Thompson Trailer Corp. has developed a delivery truck with a van that can be alternately lowered to street level and raised 52 inches above the ground.

Support for the rear wheels is obtained by stub axles joined to the frame with an elliptical steel arm, which lies in a diagonal position when the van is raised and in a horizontal position when the van is lowered. The wheel is also supported by a half spring and hydraulic cylinder in the ordinary running position and the hydraulic cylinder when it is raised or lowered.

The hydraulic cylinder is constructed of conventional parts—valves, fittings, hose and the like. On present models, the motor turns at 3500 rpm to exert hydraulic pressure of 1500 psi. Controls for the hydraulic apparatus can be installed in the cab or at the rear of the truck according to customer preference.

According to its manufacturers, the Thompson Lo-Loader can reduce unloading time to a third, since it is not necessary to lift cargo to conventional truck height by human labor or in small loads on a hydraulic tail-gate. Also the truck can be driven whenever the van has road clearance, which eliminates the need to raise and lower it for multiple deliveries. Payload for the largest model of this truck will probably amount to 15 tons.

The interior of a 16-ft. truck is 7

ft. 6 in. high and 7 ft. 10 in. wide. The space between the wheel nacelles measures 5 ft. 2 inches. The Lo-loader design is applicable to a flat bed, a refrigerated or a semi-enclosed type of body as well as the van.

Thompson says that they are able to supply a larger body from a cubic point of view than is found on standard trucks on standard chassis, because there is no running gear. Also, the length or width of the truck frame or chassis is not restricted.

Thompson is setting a base price of about $8500 for a Lo-Loader using a 5103 Chevrolet chassis and truck.

Vinyl Laminate Process Licensed by U. S. Steel

U. S. Steel has obtained a license to utilize an adhesive and automatic bonding technique known as Marvibond in the manufacture of its steel products. Developed in 1954 by U. S. Rubber Co., this process applies a 4 to 20 mil film of polyvinyl chloride to sheet steel and other metals.

Confirming the agreement reached between U. S. Rubber and U. S. Steel, a spokesman for the latter said that development of specific applications for the vinyl laminate to sheet steel is being conducted at U. S. Steel

Particular attention is being given to forming and deep drawing characteristics of the process. U. S. Rubber has explored successfully these factors, in such forming operations as shearing, punching, drilling, brakepress bending stamping, roll forming and cold drawing.

Prior to U. S. Steel's licensing action, several successful applications of Marvibond have been reported. They include: finished panels for interior and exterior of homes, store fronts, flush doors for office buildings and the interiors of fibre drum containers packaging chemicals.

Still in the preliminary stage, U. S. Steel's interest in Marvibond is directed at specific markets where the need for an inexpensive, wear-resistant surface and color-finish for metal parts is apparent.

The automotive industry as well as the appliance industry would appear to be the prime market for such a process which virtually eliminates all finishing operations on a part.

Hart Jordan, engineer . . . with Kollander Engineering Co., places the rotor in the "reactor engine" prototype which has combustion taking place in the rotor rather than in the combustion chamber. This model, according to Jordan, has already reached an efficiency of 50% as compared to 30% achieved by an ordinary piston engine in the average passenger car.

Predict 50%-80% Efficiency for New Turbine-Type Engine

A small, turbine-type engine in which combustion takes place in the rotor rather than in the combustion chamber, and which, with the aid of a non-conventional regenerative cycle, may reach an efficiency of 80% is being developed by the Kollander Engineering Co., Albuquerque, N. M.

According to Melvin M. Kollander, president, and Hart Jordan, engineer, their "reactor engine" operates on the principle of turbine engines, except that a higher efficiency is achieved by combustion of gasses at constant volume as opposed to constant pressure.

Present plans call for the engine to weigh 175 lb (as compared to 400 lb for the average passenger car engine) with dimensions of 18 x 30 x 21 in. It will develop 285 bhp or rated hp at 2000 rpm output shaft, and will burn diesel fuel or fuel oil. Little more than a year ago Chrysler Corp. cross country tested its experimental turbine engine which was rated at 160 hp with the idling speed of the compressor turbine at 20,000 rpm and a max. driving turbine speed of 50,000 rpm. The engine of this 1956 Plymouth with reduction gears was 32 x 33 x 28 inches.

The prototype (rotor size of this model is only 3.265 in. dia and 4.5 in. length) already has operated at better than 50% efficiency, Kollander said. He added that since this was accomplished without benefit of his "unconventional" regenerative cycle, he has reason to believe that with the cycle an 80% efficiency can be obtained. This regenerative cycle will permit the engine to recirculate the remaining energy in exhaust gases.

The engine has only one moving part—the rotor—while the entire power plant consists of only 6 moving parts. Kollander explained that the engine's reactors will last for a period equivalent to the expected lifetime of the average high-priced passenger car, or about 125,000-130,000 miles.

A second model scheduled for production will have a rotor measuring 8 in. diameter and 12 in. length. Calculating from power curves and the proposed volumetric flow. Kollander expects this second model to develop 285 hp at 8000 rpm, and 2,000 rpm at the output shaft. Fuel consumption is expected to be lower than the first model.

Kollander and his staff suggest that their engine, if and when it is licensed to manufacturers, can be valuable as a power plant for propellor-driven aircraft and land transportation units.

Salary Raise Outlook Dim For Military, Government Engineers

Industry is now offering scientists and engineers salaries that run as much as 15 or 20% above those paid by the Defense Department, creating a powerful lever to pry badly needed technical personnel away from Government service. Yet, despite pressure from the Pentagon, most Washington observers believe the odds are against a pay raise in the near future for civilian or military personnel.

Recommendations by the Defense Advisory Committee on Professional and Technical Compensation headed by General Electric's Ralph J. Cordiner provide a basis for most proposals to adjust Defense Department pay scales. At least two bills have been introduced in Congress to implement the Cordiner plan, and a Senate Armed Services Subcommittee headed by John Stennis (Dem, Miss.) has been set up to investigate it.

But for the present, the Administration is putting a damper on the plan because of the effect it would have on Government spending. About all the Administration has allowed the Pentagon to do is to provide proficiency pay of $30 a month to enlisted technicians with critical skills.

Other proposals in the Cordiner report include a 12% increase for civilian engineers, scientists and skilled technicians employed by the Defense Department with comparable in-grade pay increases to military personnel, a revision of the traditional military pay system to make merit rather than longevity a main basis for military promotion, enlargement of the military pay structure from seven to nine grades to allow more flexibility in pay for enlisted technicians, and a salary hike for senior officers to a level more in line with salaries paid in industry to men with comparable responsibility.

The Cordiner Committee based its recommendations on serious shortages of technical personnel. Employment of aeronautical engineers, the report reveals, is now running 27.2% short of requirements, electronics engineers 24.8% short, mechanical engineers 24.4% short, marine engineers 19.6% short electrical engineers 18.6% and physicists 16.6%.

Equipment in the IT&T . . .
standards laboratory used to test and certify master mechanical and electrical devices includes this Carl Zeiss, Koestler's Absolute Interferometer. The instrument, shown here, can measure master gage blocks to within better than one millionth of an inch. An IT&T physicist checks the temperature inside the interferometer to within 1/100 C.

NBS Encouraging Private Laboratories to Take On Routine Testing, Certifying

A new standards laboratory for testing and certifying master mechanical and electrical measuring devices–an installation which will supplement and extend the work of the National Bureau of Standards–has been established by International Telephone and Telegraph at its Federal Telephone and Radio Div. at Clifton, N. J.

Speaking at recent dedication ceremonies, Dr. Allen V. Austin, director of NBS, said that demands for standards, measurement techniques, precise testing and calibration have increased so that the bureau has been hard pressed to provide direct service to the public. Standards laboratories such as the IT&T installation will ease the bureau's burden.

Dr. Austin said that the bureau will more and more assume the role of a scientific service agency, serving central or key professional organizations and calibrating master instruments and transfer standards. The bureau will also encourage private standardizing and testing laboratories to take up the resultant slack.

While several private laboratories have made available services in other fields of technology, the IT&T standards laboratory and the Eli Whitney Div. of Sheffield Instrument Co., Dayton, Ohio, are the only comparable installations in the country.

The IT&T laboratory, a 1,000,000 sq ft structure situated within the FT&R factory building, is equipped with rigid atmospheric controls, double thickness steel walls and ceilings. Electrically, the laboratory is equipped to measure voltage, current, resistance, frequency, capacitance and similar basic electrical units to accuracies of parts per thousand. Mechanically, the laboratory can provide standard testing of threaded ring gages and set plugs, plain and tapered plugs and rings, gage blocks, thread measuring wires, master gears, precision threaded parts, and cylindrical and tapered parts. The National Bureau of Standards certifies IT&T's master gages every year. It was indicated that in cases of routine manufacturers' requests for measurement of instruments or parts, the time lag in obtaining service will be minimized.

Dr. Carroll V. Newsom . . .
president of New York University, addresses the opening class session of professional engineers at the Western Electric Company's new special "campus" site in New York's Coliseum office building. Brief ceremony marks the inauguration of Western Electric's multi-million dollar graduate engineer training program developed in cooperation with six leading universities.

Western Electric Engineers Back on 'Campus'

A new effort to better utilize professional engineer talent and keep it abreast of technical advances is undergoing its initial operational phase in a multi-million dollar university program developed by the Western Electric Co. in cooperation with six leading universities.

The new program joins an expanding list of corporate engineer educational ventures aimed at helping to shore up the nation's reserve of trained technical manpower, and somewhat parallels programs offered by such firms as General Electric Co., Westinghouse, Bell Telephone Laboratories and General Motors Corp.

Western Electric's new curriculum offers no formal academic credits for course work completed, but students are graded on class assignments. Cost of the program will be borne entirely by the company and will entail an estimated $2-million annual outlay in operating expenditures. The company's most recent large-scale back-to-school movement is likened by Timothy E. Shea, Vice-President-Engineering, to the equivalent in cost and administrative effort to establishment of a new engineering school of 1,000 full-time students.

Designed in part for young engineers who have served up to one year in regular, on-the-job assignments, the program will eventually include all segments of the firm's engineering body.

Initial courses, running approximately nine weeks in length and conducted at three special campus centers in New York, Chicago and Winston-Salem, N. C. and at New York University, Northwestern, Illinois Institute of Technology, Cornell, Duke and North Carolina State, will highlight fundamentals of basic communication systems and product design principles. Intermediary and advanced courses for more experienced personnel will vary in length of time and include intensive training in such subjects as operations research, industrial control devices, computer theory and advanced tool design.

When fully operative, the program will include a staff of about 65 full-ministrative personnel with an equal time company instructors and ad-number of instructors recruited on a part-time basis from cooperating university staffs. Eventually it is expected that some 2,400 Western Electric engineers will participate in the full-time off-the-job training program annually.

Steel Price Up, Aluminum Expected To Follow

Immediate competitive advantages to be gained by light metal producers as a result of the recently announced $6 per ton hike in basic steel prices appear to be softened by expected announcement soon of a rise of up to one cent per lb. in the base price of pig and ingot aluminum, plus the long-range rather than short-range aspects of most research and development programs being conducted by major aluminum companies.

According to an industry spokesman, it is expected that pig and ingot aluminum base price will be upped shortly in keeping with increased production, distribution and labor costs, somewhat paralleling the steel price increase. However, it is pointed out that in the case of most aluminum producers, research efforts to broaden the product field are only nominally tied to any price increase steel or other metals producers may announce.

Aluminum spokesmen note that particular product fields which look promising for the future include automotive, beverage and food container fabrication, and electrical transmission lines, areas once dominated by steel, tinplate and copper. Recent inroads made by aluminum in the automotive field include current experimentation with a 6-cylinder aluminum engine block, transmissions loaded with aluminum, both in castings and extruded form, plus engine radiators and color annodized grills made of aluminum.

Recently, reports have cited the steady growth in the use of aluminum in automotive fabrication, from 15 to 20 lbs. of the light metal in the average vehicle a few years ago, to somewhere close to 40 lbs. today. And aluminum producers contend the end of the road is not yet in sight. One aluminum producer has reportedly met with success in designing and turning out an aluminum overhead crane, replacing structural steel in the basic framework. In the near future, says another aluminum company spokesman, his firm will announce important developments resulting from experiments a leading railroad operator is running with aluminum doors for boxcars.

Design Specialist Looks At Ti's Future

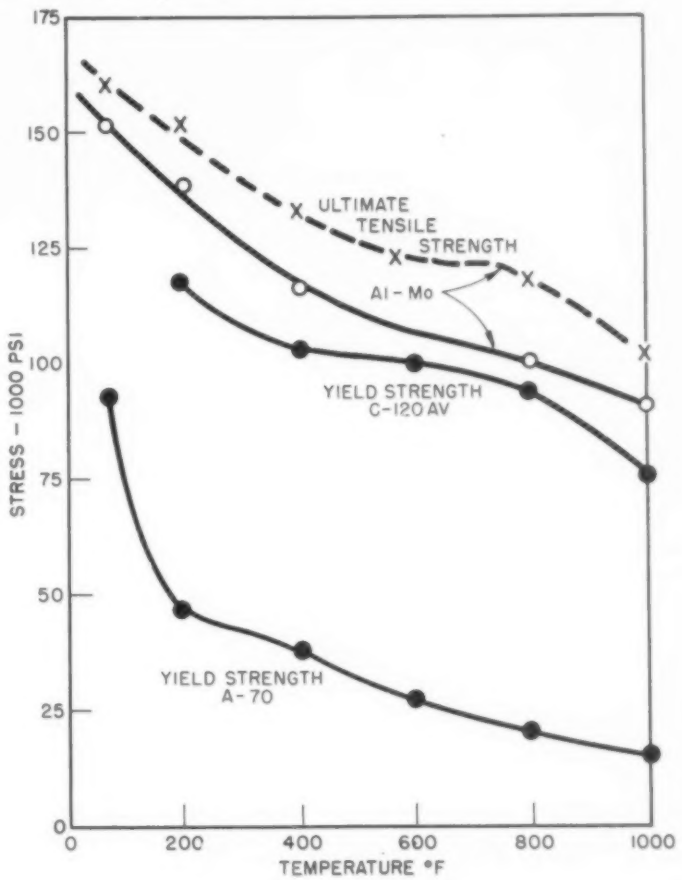
The future of titanium, proclaimed a wonder metal 10 years ago, lies not in competing directly with steel and aluminum, but in special applications where its properties are required, according to I. J. Wilson, design specialist with North American Aviation.

"The principal advantage that titanium offers to the designer," says Mr. Wilson, "are corrosion resistance and a high strength-to-weight ratio at elevated temperatures. Its principal disadvantage is high cost and relatively poor formability.

"This points to a rather limited industrial use for titanium, inasmuch as it lends itself to the requirements of the aircraft and missile industry, where weight is of prime consideration. Even here, where severe formability is required, steel has the advantage.

"Also in the areas of extreme temperature requirements, steel shows a better strength-to-weight ratio. This may be offset by stiffness requirements that dictate a heavier gage than required for strength. Here, steel loses its advantage over titanium.

"The new heat treatable titanium alloys will open new areas of use. However it is believed that in the forseeable future the vast majority of the titanium produced will be used for aircraft. A limited amount will be used in fields where a cheaper, more formable material will not suffice.



A new titanium alloy . . .
developed by Rem-Cru Corp., having a nominal composition of 6½% aluminum and 3¾% molybdenum, shows promising properties for jet engine discs and blades, and high strength-lightweight airframe forgings. As shown on the chart above, tensile strengths exceeding 160,000 psi with good ductility in heated treated sections over 2 in. thick have been obtained with this alloy known as C-130AMe. Short-time yield strength is also charted for temperatures up to 1000 F, comparing favorably to aluminum-vanadium compositions such as C-120AV.

GM Models May Spurt '57 Foreign Car Sales Here to Quarter Million

The 1957 Opel Olympia Rekord, above . . .
produced by GM at its West Germany plant, provides the prospective American car buyer with an idea of what GM will introduce in the U. S. next Fall in the way of a low-priced European car. At right is the Vauxhall Victor, a 4-cylinder, 52-55 Hp, sedan which GM will distribute on a limited scale through the Pontiac div. to the Atlantic Coast area. The Victor sells in England for $1,400 in U. S. dollars while the Opel Rekord is list priced at $1,450. GM has announced no prices for U. S. distribution.

With sales of European cars in the U.S. expected to approach the quarter-million mark during 1957, GM will introduce in September two of its foreign-made models in an effort to capitalize on the zooming popularity here of the low-priced, high fuel mileage, small-sized car.

GM's entries in this market will be the Vauxhall Victor, a 4-door sedan with a 4-cylinder, 52-55 hp engine and 98-in. wheelbase; and the Opel Rekord, about which little is known at this date. The Vauxhall Victor is made in a GM plant in England, and will be distributed by Pontiac Div., while the Opel model will be produced at GM's West Germany plant, and distributed by GM's Buick div.

Both cars will be distributed on a limited scale in keeping with present inventory conditions prevalent among European car makers. In sharp contrast with U.S. car producers (some 800,000 units are presently backed up in inventory in U.S. factories) the European car producer is hard pressed to meet buyer orders here. Waiting lists for the German-made Volkswagen are not unusual. The situation is no different with the German Isetta-300, the Austin A-35, the Citroen-2CV, the Renault 4CVL and the Ford Anglia series.

Reasons for the limited supply of these low-priced, foreign cars here include lack of shipping space, and the radically different merchandising approach taken by the European car producer.

As one German automotive official explained it, "We change our model design only infrequently. We do not scramble for retail outlets, nor do we discount our prices. Rather, we concentrate on gradually increasing our production output to supply a world-wide market, which, incidentally, is not limited to the U.S."

That the U.S. is becoming an increasing portion of this market is evidenced by the growing number of foreign car registrations in the U.S. since 1954 when there were only 25,385. In 1955 this figure was doubled and in 1956 it was redoubled to pass the 100,000 mark. This year the foreign car makers expect to at least double this figure, and, with GM in the picture, the quarter-million mark may be reached.

The less expensive foreign cars available on the U.S. market range in price from $1,000 to $1,600. While GM officials have announced no prices for their Vauxhall Victor and Opel Rekord models, a price tag of less than $2,000 is expected despite import duties and excise taxes each amounting to 10%, plus shipping costs. This cost would be somewhat more than a $1,600 Volkswagen.

Inversely, there appears little likelihood U.S. car makers will launch an export drive to compete with British and European auto producers. Three reasons, advanced by an official Vauxhall spokesman, were (1) America doesn't figure to improve on Europe's integral body construction methods, (2) U.S. labor rates exceed Europe's even in the making of small cars, and (3) several export market areas have no U.S. dollars. According to Vauxhall, only a demand for more than ½ million cars annually could trigger such a U.S. tooling effort.

Stainless Type Sheet Made By Chromium Diffusion

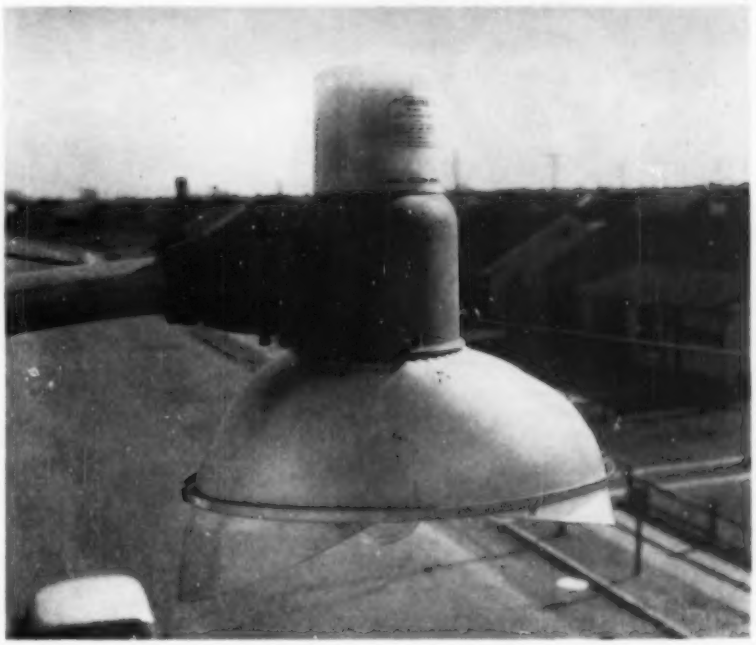
A substitute for stainless steel, made by diffusing chromium into the surface of low carbon steel, is now being marketed in sheet form by Chromalloy Corporation, White Plains, New York. The sheet has a 40-50% chromium alloy surface. It sells for around 49¢ a pound compared with warehouse quotations of 76¢ to $1.50 a pound for stainless.

The chromalloy material, produced in sheets up to 2 x 5 ft. and in gauges up to ⅛ in., can be fabricated by any process with the exception of grinding and machining, according to the manufacturer. As for welding, it is suited to the projection, spot, or seam processes. Fusion welding can be accomplished by using stainless steel rods, and brazing by use of fluoride flux at temperatures slightly higher than ordinary. This sheet can also be bent, drawn, spun, or staked with about the ease of low carbon steel.

The chromalloy sheet withstands operating temperatures as high as 1500 F for hundreds of hours and 1200 F indefinitely. Its heat and oxidation resistance is within the range of 18-8 stainless. After 1000 hours at 1200 F. tests indicate chromalloy will gain 2-5 mg/cm² in weight.

The sheet is said to be resistant to strongly oxidizing acids such as nitric acid. Its corrosion resistance is about on par with type 430 stainless steel indoor, outdoor, or in a chemical environment.

Chromalloy Corp. acquired its diffusion process under an exclusive license with Diffusion Alloys, Ltd., a British firm. Since it acquired its license in 1951, Chromalloy has confined its production activities to chromizing custom parts rather than treating sheet.



This light sensitive switch . . .
called a Lumatrol, shown here mounted on an individual street lamp, consists of a switch cover molded from tough Tenite butyrate plastic with a translucency which permits approaching darkness or daylight to trigger the switch, turning the light on or off automatically. The switch is used by industry in large plant areas where exterior lighing of yard areas and grounds is necessary. Utility companies also use the switch. Manufactured by Micro Balancing, Inc., the switch has a cover molded by Popular Plastics Products Corp with Tenite butyrate supplied by Eastman.

Add spin welding to the list of techniques for joining thermoplastic parts —especially polyethylene and nylon whose solvent resistance makes bonding by other methods difficult.

A frictional technique in which heat generated by rotating two parts against each other melts their surfaces just enough to obtain a firm bond, spin welding is being applied by DuPont in the production of tool handles, instrument knobs, pipe fittings and new items like multi-colored nylon aerosol bottles.

Spin welding can be applied to almost any set of parts with circular joints, using a modified lathe or drill press. DuPont reports that best results are obtained when the machine is set up so that one part can be held stationary during the initial period of contact, while the other is rotated. Then both parts should be allowed to rotate freely after the surface is molten and while the joint sets.

The market for porcelain enamel on aluminum which amounted to 3.5 million sq ft in 1956 will rise to 5.2 million sq ft this year and to 23 million sq ft by 1961, according to a forecast released by the Porcelain Enamel Institute's Aluminum Div.

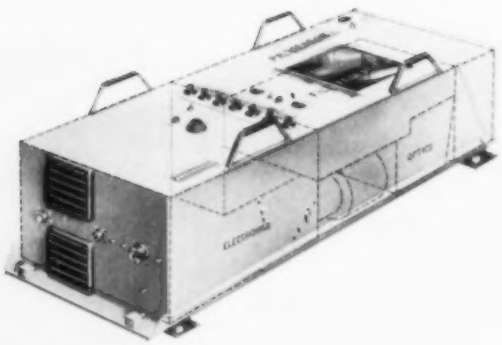
The Institute based its projections on the predicted growth of the aluminum industry and on an anticipated steady increase in existing applications for porcelain enamel and the development of new products.

The first digital process control computer available to industry, soon to be introduced by Ramo Woolridge Corp., is designed to serve as the central operating unit of closed loop digital systems in the process industries.

The new computer, called the RW-300, will automatically read process instruments, perform computations necessary to relate these readings to process objectives, determine the control actions that will result in the best operation and actuate process mechanisms or adjust set points on supervised control loops.

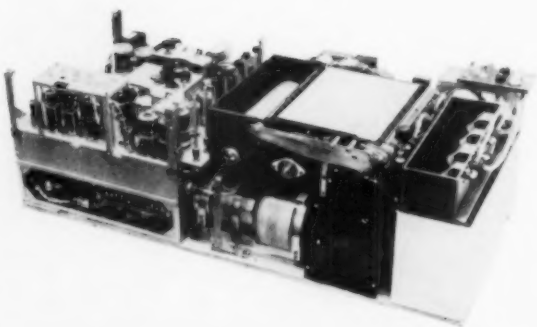
Relatively small, the RW-300 measures 55 x 28 x 36 in. and weighs approximately 400 lb. This fully transistorized computer is specifically designed to automatically control industrial processes such as oil refining, chemical manufacturing, paper making and metal processing. The RW-300 can also be used for general purpose scientific computation, and to perform the monitoring function of a data logger.

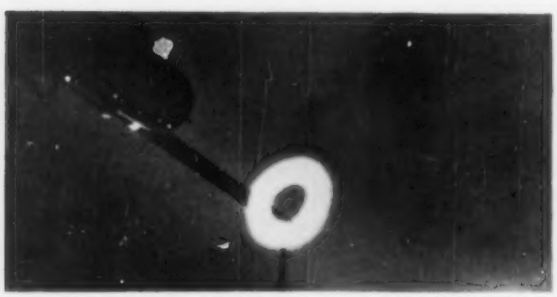
NEWS IN PICTURES

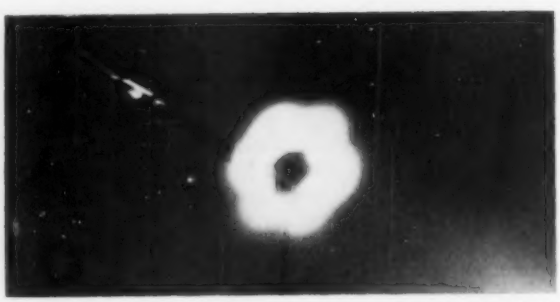


Through use of . . .

a high sensitivity film and an emulsion that will develop in ten seconds, Hycon Mfg. Co. has come up with a device that makes a continuous record of the ground beneath as it is picked up on a plane's radar, or in small reconnaissance drones. Called a radar strip recorder, it films the changing radar image on a 9½ in. wide roll of film. The film passes through a single solution for developing and is immediately projected on a 9 x 12 in. screen, then rewound on another coil for a permanent detailed record of the flight. During the developing process, the emulsion is kept at 130F. In the two initial models of the recorder an area of 45 x 60 miles is scanned to produce a map on a scale of 1 to 500,000, or a 22½ x 30 mile area to produce a map on a scale of 1 to 250,000. The recorder has manual controls for setting in a 12-mile wind drift. Hycon suggests the device will be a useful aid to precise navigation, and, if recovered from a wrecked plane, it will provide a record for analyzing the causes of the crash.







These two smoke rings . . .

were blown by the exhaust of a Douglas Aircraft Co. jet. Douglas has developed a technique of photographing smoke from the exhaust of jets which will yield data on the geometric properties of the jet's smoke —its size and shape, and their relation to the sound produced. The data helps the design of nozzles to minimize turbulence that is created when exhaust shears relatively still air. At top, left, exhaust is emitted by a normal nozzle; at bottom, right, exhaust is emitted with a noise suppressor. In the ordinary nozzle the ring has broadened, but is still sharp and clear. In the other it is diffused and therefore creates less sound. Douglas makes its photogenic smoke by injecting mineral oil into the air supply upstream from the jet exit and passing a thin slice of light through the smoke at each point to be photographed.

The Rat . . .

an amphibious trackmobile designed jointly by the Canadian Army and Canadair Ltd., Montreal, Canada, will find extensive use in cross-country travel in the far north. Weighing only 1500 lb., it can carry about 600 lb. of cargo while towing an additional 1000 lb. on sleds, and powers the rear section through a power takeoff. The Rat is built in two tracked sections linked together, and has a small gasoline engine in the front section which also powers the rear section through a power takeoff. The Rat floats when fully loaded, and the tracks give enough propulsion for crossing lakes. Fully loaded, the weight is distributed at ½ psi over its track treads. Engine is of standard air-cooled design. Top speed is 22 mph., at an engine speed of 3400 rpm developing 35 hp.

Part of . . .

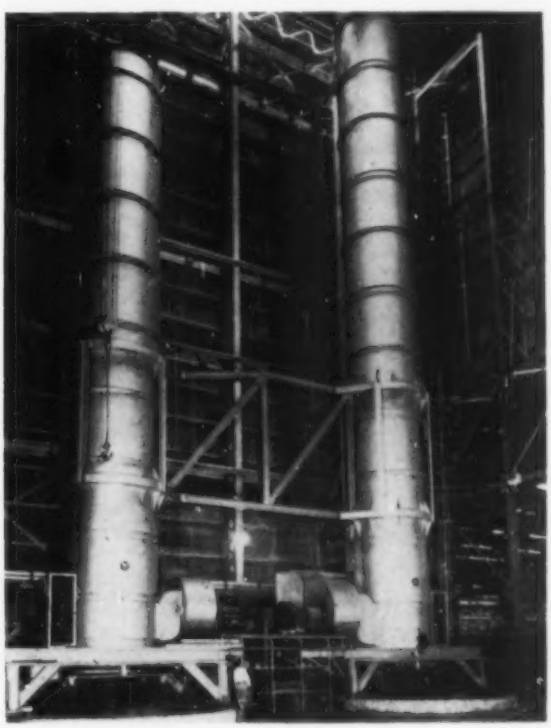
an antitank guided missile system, this 5 ft long finned weapon, known as the DART, carries a warhead capable of destroying the heaviest known enemy armor. According to reports, the missile will be effective over a much longer range and will have higher accuracy at the longer range than the conventional recoilless rifles and tank guns. DART is vehicle-launched and driven by a rocket motor using a smokeless propellant. The system is unique among guided missile systems in that it is designed as a tactical weapon for the use of front line troops. It was developed by the U. S. Army Ordnance District, Los Angeles, Redstone Arsenal, Huntsville, Ala., and Aerophysics Development Corporation.

Shown here is . . .

one of the three types of image-producing panels called Sylvatrons, just announced by Sylvania Electric Products Inc., Lighting Div., Salem, Mass., as part of their continuing development of the panelescent lighting introduced six years ago. The panelescent lamp produces light by direct excitation of phosphors in an electric field. The latest image-producing panels (still in the laboratory stage) use this principle, plus that of photo-conductance, and consist of flat glass electroluminescent panels with various control layers. These control layers are thin coatings of photo-conductive and electro-conductive surfaces. When an electrical or optical signal and a power source is applied, an image is produced. Three basic types of panels are: a panel on which a mobile dot of light can be manipulated; a panel which reproduces optically the track of a mobile spot of light, permitting storage for an indefinite time in a visible form; and a panel which reproduces a motion picture with good resolution.

The electric furnace . . .

Below, 110 ft tall and 7 ft in dia. has been designed for Harvey Aluminum of Torrance, Calif., by Westinghouse, for heat treating aluminum alloy pieces up to 80 ft long. The companion furnace, 70 ft high, is designed so that it can be expanded. Aluminum parts are suspended in the furnace at temperatures up to 800 F. Beneath the furnace, reportedly the largest in the world, is a 210,000 gal water quenching tank, 110 ft deep and 18 ft in dia. The electrical furnaces are to be used in conjunction with the 12,000 and 8000 ton hydraulic extrusion presses at Harvey under the Air Force Heavy Press Program.



TECHNICAL NEWS

News Briefs

Rear-end transmissions are still two to three years away, while elimination of the spare tire is only slightly less remote.

Chrysler Corp. has shelved its plans to move the transmission from the car's midsection in the 1958 models until drawing board bugs have been ironed out. The advantage of such a switch to the average car buyer lies in thinning down the unsightly and sometimes uncomfortable hump in the car's midsection.

More pronounced than ever in the low-slung 1957 models, this hump will became increasingly apparent in the still lower-slung models to come. Its elimination would provide automotive engineers and stylists with new avenues of exploration for improvements, such as front-to-rear weight distribution, split axles and suspension, to name just a few.

The captive air tire—described by Goodyear as the "tire with the built-in spare"—will eventually eliminate the need for the spare tire. Already Chrysler plans to drop the "Fifth Wheel" in favor of just four captive-air tires in its 1958 station wagons. However, until the spareless car gains acceptance, spare tires will be provided on all the passenger cars.

All of the Big Three automotive companies have been studying the possibilities of the spareless car as well as the feasibility of the rear-end transmission. None of them are quite ready yet.

Seeking to more efficiently evaluate the adhesion property of protective coatings for modern aircraft, the National Bureau of Standards Washington 25, D. C., has developed an electronic averaging device called the integrometer.

The integrometer, developed in the NBS plastics laboratory, will be used in conjunction with the adherometer, an instrument which measures the force required to strip a coating from a metal surface. By itself, the adherometer posed dial gage reading and recording difficulties during long stripping runs. The integrometer—a device which converts the variable stripping force measured by the adherometer into electric impulses then adds the impulses to provide a single average value which can be read directly from a standard recorder —relieving the adherometer of this dial gage function.

The "Educator Reactor", an improved version of the Argonne nuclear reactor, will soon be made available to universities and industry, it was announced jointly by Atomics Div. of American Machine & Foundry Co., and the General Nuclear Engineering Corp., Dunedin, Fla. According to the agreement, GNEC will design and AMF engineers will handle the construction of these reactors to be used primarily for training students and industrial researchers in reactor physics and engineering, nuclear physics and related fields.

Rated at 10 kw for continuous-duty operation, this water- and graphite-moderated reactor is characterized by minimum excess reactivity, low fission-product content and self-limitation of power.

If the drop forging industry continues its current sales increase trend, annual sales—which totaled $693 million in 1956—should reach the $850-million mark by 1961, and go over the $1 billion mark by 1965. This was the forecast offered by C. H. Smith, Jr., president of Steel Improvement & Forge Co., Cleveland, during a speech before the second annual meeting of the Drop Forging Assn. at Mackinac Island, Mich. He added that last year several drop forging companies registered sales totals that amounted to more than the entire industry's sales 25 years ago.

A new corporation with United States and Belgian industrial ownership, NDA Enrope, has been formed in Brussels to provide for rapid atomic energy development in the six Euratom countries and their colonies, possessions and territories. Principal owners of NDA Europe are Nuclear Development Corp. of America of White Plains, N. Y., and Societe Generale des Minerais of Brussels. Societe Belge pour l'Industrie Nucleaire (Belgonucleaire) is also a participant.

Announcement of formation of the new corporation follows earlier reports citing Belgian plans for becoming one of the world leaders in the nuclear energy field, owing in part to control of rich uranium ore deposits in the Belgian Congo. Concentrated developmental facilities are available at home and an extensive research program for training scientists and engineers in cooperation with the U. S.

Engineering employes of Boeing Airplane Co., Seattle, have accepted a new one-year labor contract which calls for a 4% salary increase with an additional "unleveling increase" of up to 2% for those engineers earning more than $572 a month. "The 4% increase, retroactive to May 11, was determined by the increase in salaries presently offered new engineers over the salaries offered new engineers last year," said Dan Hendricks, Jr., president of the Seattle Professional Engineering Employes' Association. The "unleveling increase," which is determined on a sliding scale from zero at $572 to 2% at $700 or more, is intended to compensate for previous years when the salaries of beginning engineers increased faster than those with more seniority.

The contract covers 5700 employees at Seattle and 1300 at Witchita, Kan. Some 60% of engineering employes will benefit from this "unleveling increase" which draws its description from the association's charge that the higher salaries paid new engineers had a tendency to level off all salaries and resultantly failed to compensate for the experience of the older engineers.

Two plastic compounds, useful to vacuum forming, have been developed by Smooth-On Mfg. Co., Jersey City. The first, a flexible polymer, PF-100, is used to make the mold which is cured by polymerization at room temperature. In its cured state, it is resistant to solvents, oils and greases, and will withstand intermittent service temperatures to about 200 F. The second plastic is a metal-filled epoxy resin, Metalset Al, used in making the casting which cures in two stages. In the first stage, the Metalset Al sets at room temperature; in the second, it bakes at 150 F for about 12 hrs to attain the full cure.

COMING EVENTS

AUGUST 11-15

First National Conference on Applied Heat Transfer, Pennsylvania State University, University Park, Pa. Sponsored by the Heat Transfer Div. and the Central Pennsylvania Section of the ASME. The theme will be Applied Heat Transfer, and papers are being solicited which bear directly upon heat transfer applications. Particularly sought are papers dealing with the design, construction and use of heat exchangers, economic and practical problems associated with insulation, methods of instrumentation and tests, and the results of research which may be applied in industrial practice.

AUGUST 20-23

Western Electronic Show and Convention (Wescon), Cow Palace, San Francisco, Calif. More than 200 papers will be scheduled under general headings including: automatic control; circuit theory; component parts; electronic devices; electronic computers; engineering management; industrial electronics; instrumentation; military electronics; nuclear science; production techniques; reliability and quality control; and telemetry.

AUGUST 26-28

1957 Gas Dynamics Symposium, at the Technological Institute, of Northwestern University, Evanston, Ill. The theme will be "Transport Properties in Gases at High Temperature and Pressures." One object will be to define the art in both theory and experiment for the determination of the transport properties of gases, with particular reference to extreme conditions. Present and future need for data with respect to application and design will be indicated. For further information contact Dr. Ali B. Cambel, Gas Dynamics Lab., Northwestern Univ., Evanston, Ill.

SEPTEMBER 4-6

Special Technical Conference on Magnetic Amplifiers, Penn Sheraton Hotel, Pittsburgh, Pa. There will be five technical papers on "New Circuits and Techniques," twelve papers on "Analysis and Design," and six papers on "Applications."

SEPTEMBER 9-13

12th Annual Instrument & Automation Conference, Cleveland Public Auditorium, Cleveland, Ohio.

SEPTEMBER 9-13

3rd Annual Titanium Lecture Program, New York University, College of Engineering. Attendance is limited. For further information write to Dr. Harold Margolin, New York Univ., Univ. Heights, 53, New York, N. Y.

SEPTEMBER 24-25

6th Annual Industrial Electronics Symposium, Morrison Hotel, Chicago, Ill. Major subjects will be: Development of Transducers and Other Elements of Industrial Electronics Systems, and Integrated Systems for Industrial Electronic Control. Inquiries should be sent to E. A. Roberts, Union Thermoelectric Corp., 2001 Greenleaf St., Evanston, Ill.

SEPTEMBER 27

Society of Plastics Engineers regional technical conference at Hotel Niagara, Niagara Falls. Four phases of Hot Runner Molding will be discussed by four speakers. For further details on the conference contact Mr. R. W. Miller, 3 Hillview Ct., Lewiston, N. Y.

OCTOBER 8

Upper Midwest Section of the Society of Plastics Engineers, Isocyanate Symposium at the Curtis Hotel, Minneapolis, Minn. Applications of isocyanate based polymers as coatings, foams, adhesives and potting compounds will be major subjects. For further information contact Mr. William Brooks, 1139 Carl Street, St. Paul 9, Minnesota.

OCTOBER 10-11

Thirteenth annual New England Section Conference of the Society of the Plastics Industry at Wentworth-by-the-Sea, Portsmouth, N. H.

OCTOBER 10-11

National Noise Abatement Symposium, Hotel Sherman, Chicago, Ill.

OCTOBER 13-17

Annual Pressed Metal Institute, Castle Harbor, Bermuda.

OCTOBER 14-18

International Industrial Development Conference, Fairmont Hotel, San Francisco, Calif. The central theme—industrial development—covers both large and small scale industry and includes both domestic and international capital.

OCTOBER 16

Cellular Plastics Division Conference of the Society of the Plastics Industry at the Commodore Hotel, New York, N. Y.

OCTOBER 16-18

11th Annual Conference, New England Sections of the American Society for Quality Control, at the Hotel Stratfield in Bridgeport, Conn.

OCTOBER 17-18

National Conference on Industrial Hydraulics, Hotel Sherman, Chicago, Ill. The meeting is sponsored by the Armour Research Foundation and the Illinois Institute of Technology.

OCTOBER 17-18

1957 Annual Convention of the Magnesium Association, Biltmore Hotel, New York, N. Y.

OCTOBER 17

Cleveland-Akron Section of the Society of Plastics Engineers session on Polyethylene at the Hotel Carter, Cleveland, Ohio. Morning sessions will cover four phases of material supply: survey of Polyethylene, low density polyethylene, intermediate density polyethylene, and high density polyethylene. Afternoon sessions will cover topics pertaining to the processor and fabricator.

OCTOBER 18-19

Professional Engineers of Oregon convention at Hotel Eugene, Eugene, Ore. Principal speaker will be Dr. Joseph Kaplan of U.C.L.A.

OCTOBER 23-24

Computer Applications Symposium, sponsored by the Armour Research Foundation, at the Hotel Sherman, Chicago, Ill.

Is Industry Creating A New Breed of "Bonus Babies"?

THE STARTING SALARIES offered to this year's June graduates give the impression that industry is creating a new breed of "bonus babies." This is the term baseball fans apply to sturdy youngsters whose talent for hitting and throwing gets them payments of up to $100,000 and other benefits for signing a contract.

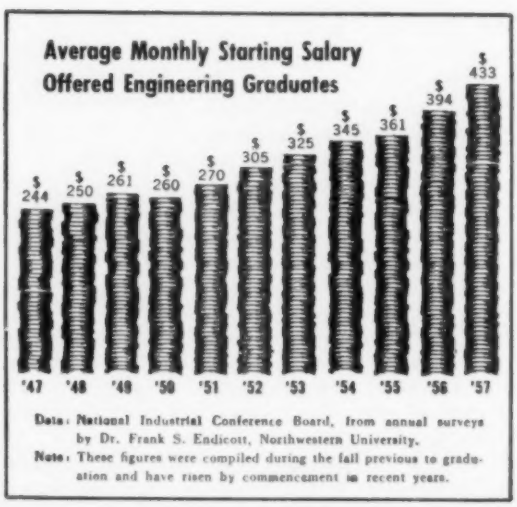
For several years industry's demand for young college graduates, especially in science and engineering, has outrun the number receiving degrees. Competition for these young people has steadily pushed up the starting salaries and has induced many companies to indulge in lavish recruiting programs. This year engineering graduates are being offered well over $400 a month, and even liberal arts graduates find numerous offers at $400 or more. Only ten years ago the salaries offered senior engineering students averaged less than $250 a month.

But any employer who assumes that high starting salaries alone will assure him the number of June graduates he wants is likely to be disappointed. A recent study by the McGraw-Hill Classified Advertising Division shows that most young engineers and scientists going into industry are more interested in their opportunities and in a company's future than they are in the size of their first paycheck.

Money Isn't Everything

In the McGraw-Hill survey, 2,596 recently-hired engineers and scientists employed in 57 companies listed the factors they had considered before accepting a position. The replies of the younger engineers and scientists—those with less than five years' experience — have great significance for employers who want to make any impression in the highly competitive market for college graduates.

- **Potential growth of the company** was listed by more young engineers and scientists than any of the 42 other items on the list as a factor that influenced greatly their decision in accepting a position.
- **Challenging opportunity** was second.
- **The company's prestige and reputation** ranked third.



Data: National Industrial Conference Board, from annual surveys by Dr. Frank S. Endicott, Northwestern University.
Note: These figures were compiled during the fall previous to graduation and have risen by commencement in recent years.

● **Progressive research and development program** was fourth.

● **Starting salary** ranked only **seventh.**

Job and Future Most Important

As a group, the factors relating to the nature of the job, its future and the company's future had by far the greatest influence in attracting young engineers and scientists to their present positions. These include three of the top four attractions—potential growth of the company, a challenging opportunity and a progressive research and development program. Other factors in this group are the company's facilities, quick advancement, self-direction or little supervision, chance to work in a certain field, small size of company and rewards for individual accomplishment.

The second most important group of attractions had to do with prestige. These include the company's prestige and reputation, executive or professional standing and association with leading men in the field. **Third in importance were financial considerations** — starting salary, regular salary increases, financing of relocation, paid vacations and holidays.

A less important group of factors influencing young scientists and engineers were essentially social. Geographic location and educational facilities in vicinity ranked fairly high. But recreational facilities, suburban or country living, pleasant housing and cultural considerations had little appeal.

Ranking lowest, by a good margin, were factors having to do with security—permanent position; health, life and surgical insurance; retirement or pension plan; and sick leave.

It is interesting to note that some of the factors which influenced the **smallest** percentage of young engineers and scientists were country club memberships, use of company car, at-cost or low-cost eating place, travel opportunities abroad and being able to buy the company's products at a discount.

A Lesson For Employers

The lesson of this survey to employers who hope to recruit more young engineers and scientists is clear. High salaries and other financial appeals are important. But, **at a time when high starting salaries are offered in abundance, our young graduates are interested even more in being with companies that will grow and in jobs that will permit them to grow. They are interested in jobs that offer opportunities for advancement, financially and professionally.**

* * *

Were the young scientists and engineers who participated in the survey trying to impress somebody with their motives? If so, it could only have been to impress themselves, for all were asked to return their questionnaires unsigned.

What Factors Influence the Job Selections of Young Engineers and Scientists?

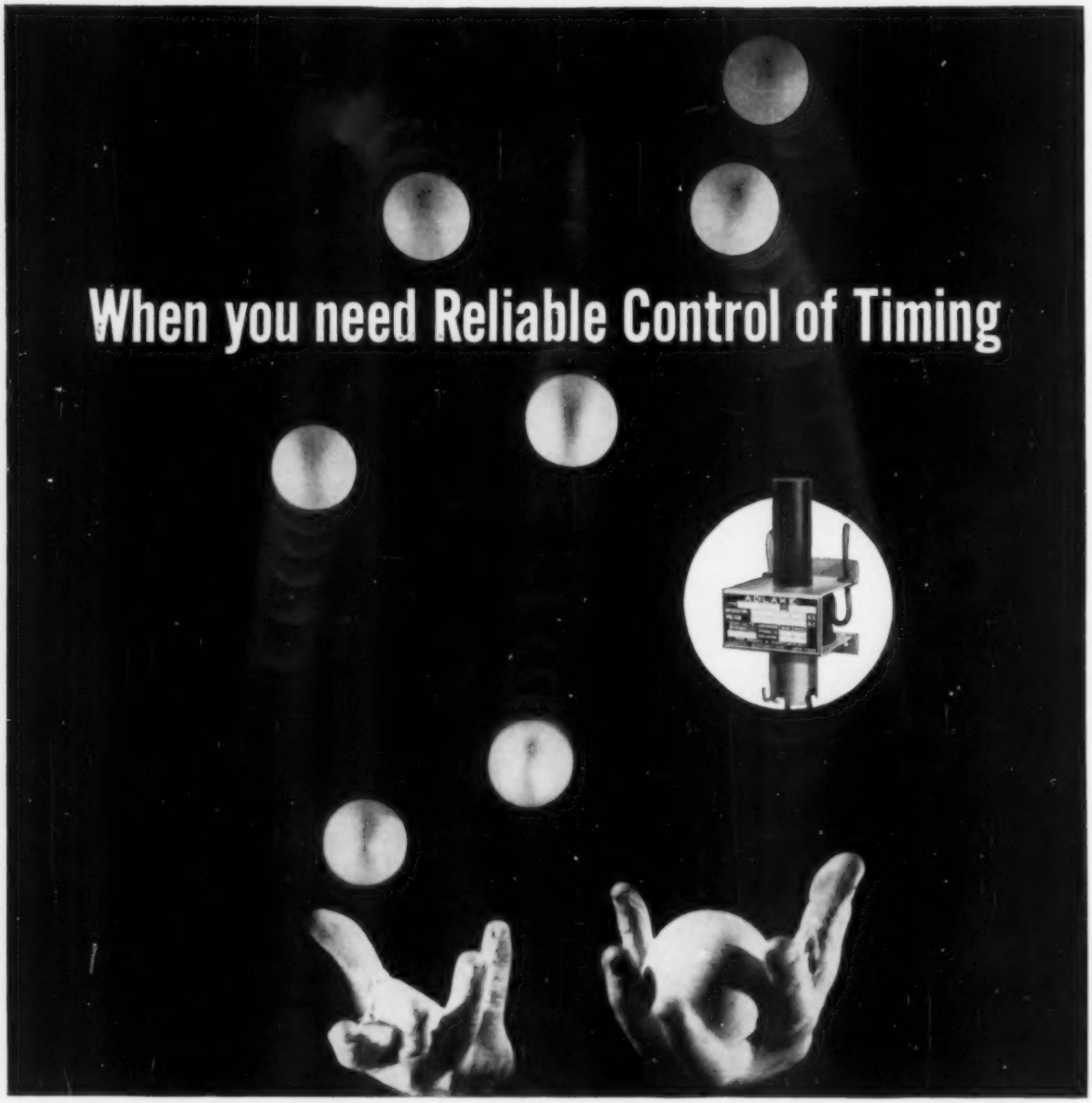
Factors Influencing Decision Greatly	Percent Listing Factor
Potential growth of company	55%
Challenging opportunity	53
Company's prestige, reputation	44
Progressive research and development program	41
Geographic location	37
Permanent position	35
Starting salary	34
Educational facilities in vicinity	33
Regular salary increases	31
Chance to work on specific project, or in certain field	27
Company's facilities (laboratories, technical libraries, etc.)	25
Tuition for graduate study	25

Based on replies by recently-hired engineers and scientists with less than five years' experience to questionnaire distributed by McGraw-Hill Classified Advertising Division.

This message is one of a series prepared by the McGraw-Hill Department of Economics to help increase public knowledge and understanding of important nation-wide developments. Permission is freely extended to newspapers, groups or individuals to quote or reprint all or parts of the text.

Donald C. McGraw
PRESIDENT

McGRAW-HILL PUBLISHING COMPANY, INC.



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- **Mercury-to-Mercury contact of Adlake Relays gives ideal snap-action with no pitting, sticking or burning.**
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- **Adlake Relays are quiet, chatterless and require no maintenance whatever.**

If you have a control problem, our engineers will be happy to help you solve it. There's no obligation. Write The Adams & Westlake Company, 1169 N. Michigan, Elkhart, Indiana.

You are invited to Booth 1505
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original and largest manufacturers of plunger-type relays

Power Capacity of Spur Gears

CHARLES TIPLITZ
Chief Engineer, J. M. Lehmann Company, Inc.

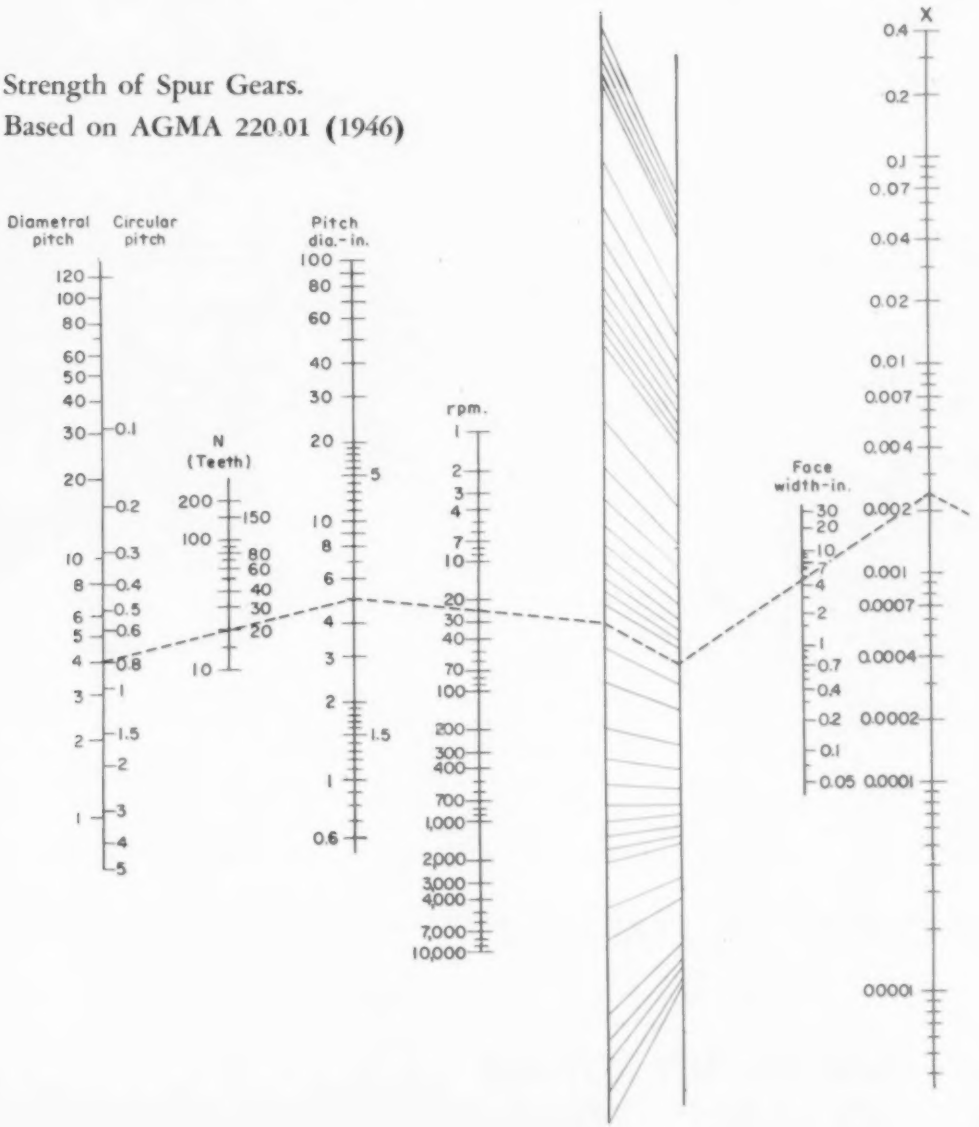
MAXIMUM RATED HORSEPOWER that can safely be transmitted by a gear depends upon whether it runs for short periods or continuously. Capacity may be based on tooth strength if the gear is run only periodically; durability or wear governs rated horsepower for continuous running.

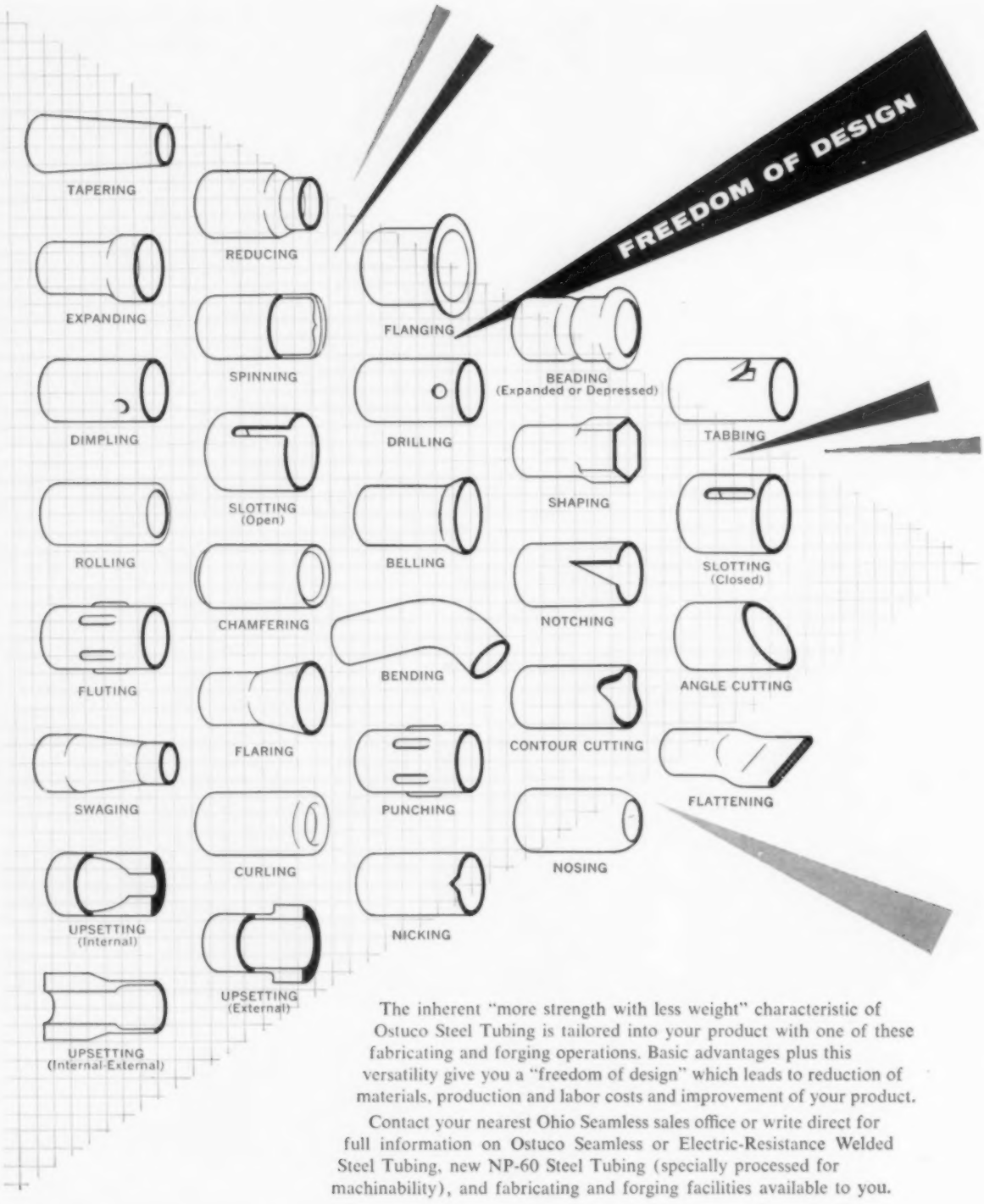
Checking strength and surface durability of gears can be a lengthy procedure. The following charts simplify the work and give values accurate to 5 to 10%. They are based on AGMA standards for strength and durability of spur gears.

Strength Nomograph is used first. Apart from the

(Continued on page 217)

Strength of Spur Gears.
Based on AGMA 220.01 (1946)





The inherent "more strength with less weight" characteristic of Ostuco Steel Tubing is tailored into your product with one of these fabricating and forging operations. Basic advantages plus this versatility give you a "freedom of design" which leads to reduction of materials, production and labor costs and improvement of your product.

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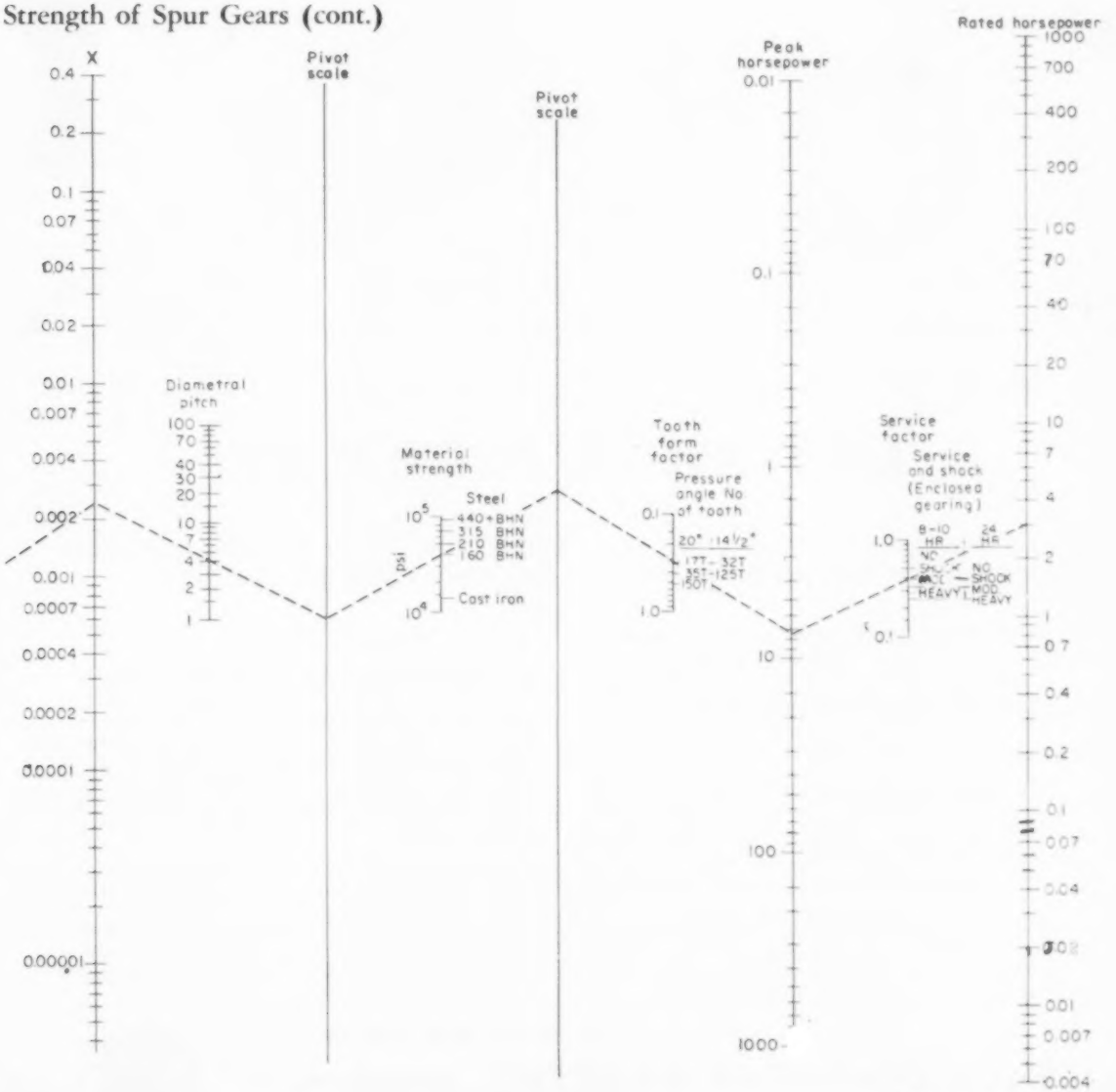
Power Capacity of Spur Gears *(Continued from page 215)*

usual design constants only two of the following three need be known: pitch, number of teeth and pitch diameter. To use the charts connect the two known factors by a straight line, cutting the third scale. From this point on the scale continue drawing straight lines through known factors, cutting the pivot scales. Between the double pivot scales the line should be drawn parallel to the adjacent lines.

Durability nomograph must be entered on scale X at the same value that was cut on the X scale on the strength chart. Both pinion and gear should be checked if made of different materials and the smaller of the values obtained should be used.

Strength of Spur Gears (cont.)



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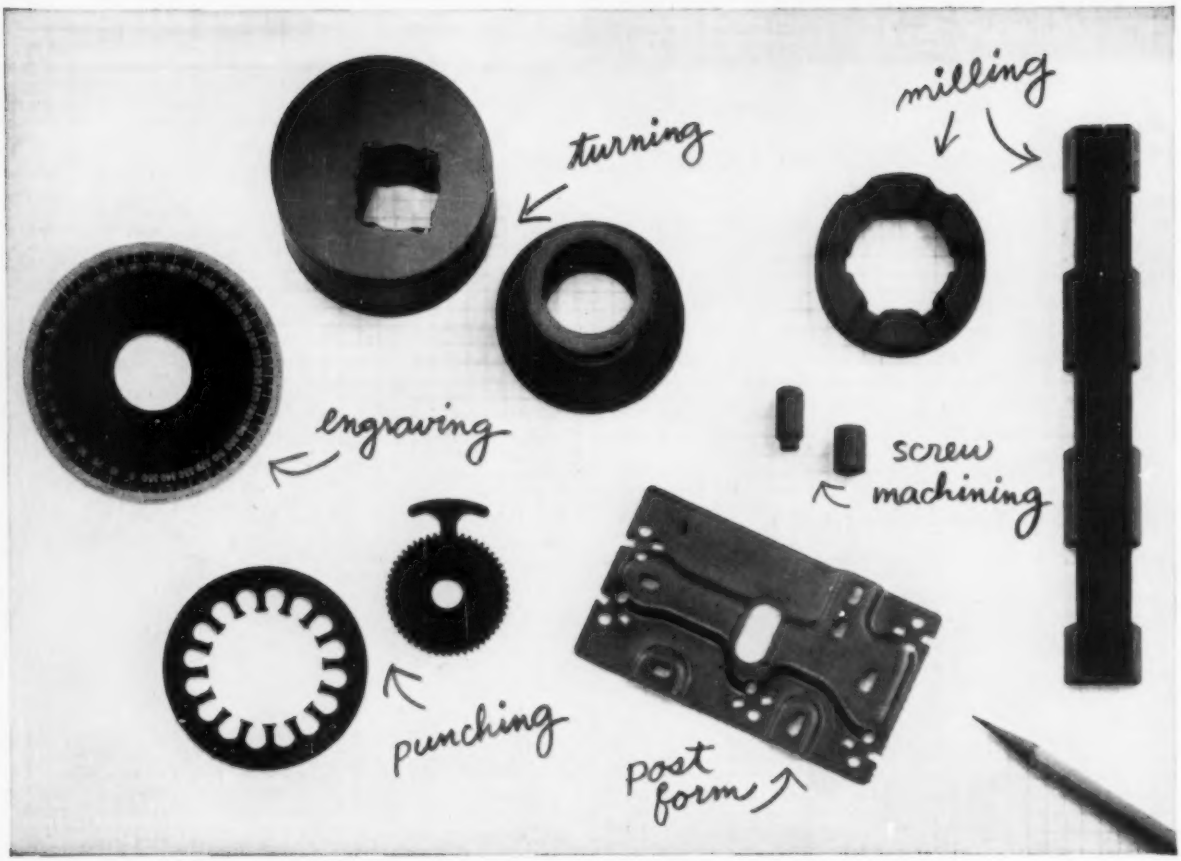

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If it's savings you're after, let MICA make it. You get quality, uniformity, prompt delivery. Consistency of base materials and workmanship all are our undivided responsibility. We know our materials and their working properties, and have equipment specially adapted for this work.

If it needs special properties, let MICA make it. We produce phenolic, melamine, silicone, polyester and epoxy laminates with paper, linen, canvas, asbestos and fibrous glass bases. Properties can be readily varied to meet special requirements.

If it needs special machining, let MICA make it. We're equipped to do punching, drilling, routing, sawing, turning, tapping, boring, threading, milling, engraving, hot stamping, fungus-proofing, plus many special operations.

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We can also mold parts of glass-reinforced polyester resin and SCOTCHPLY® reinforced plastic.

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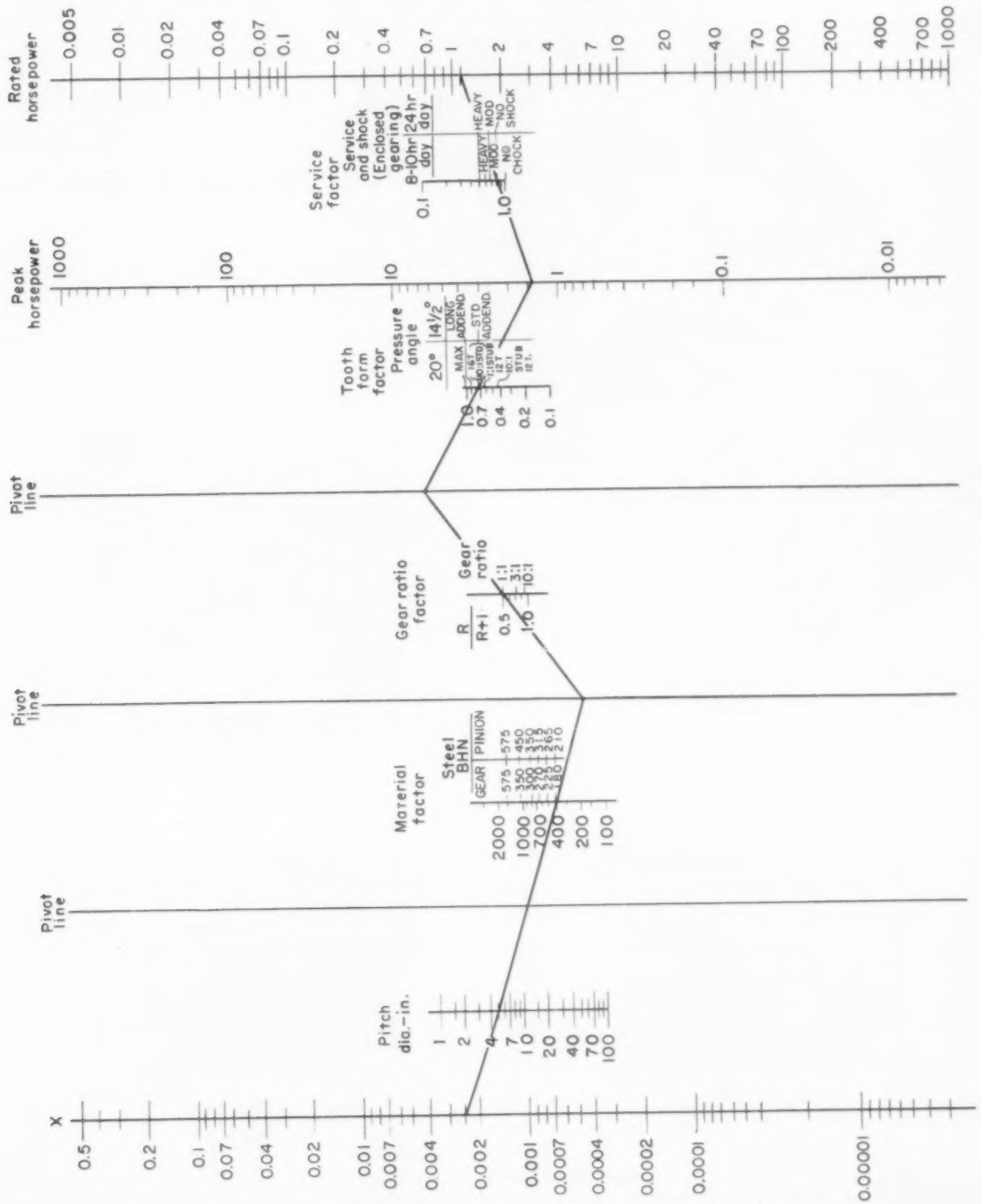
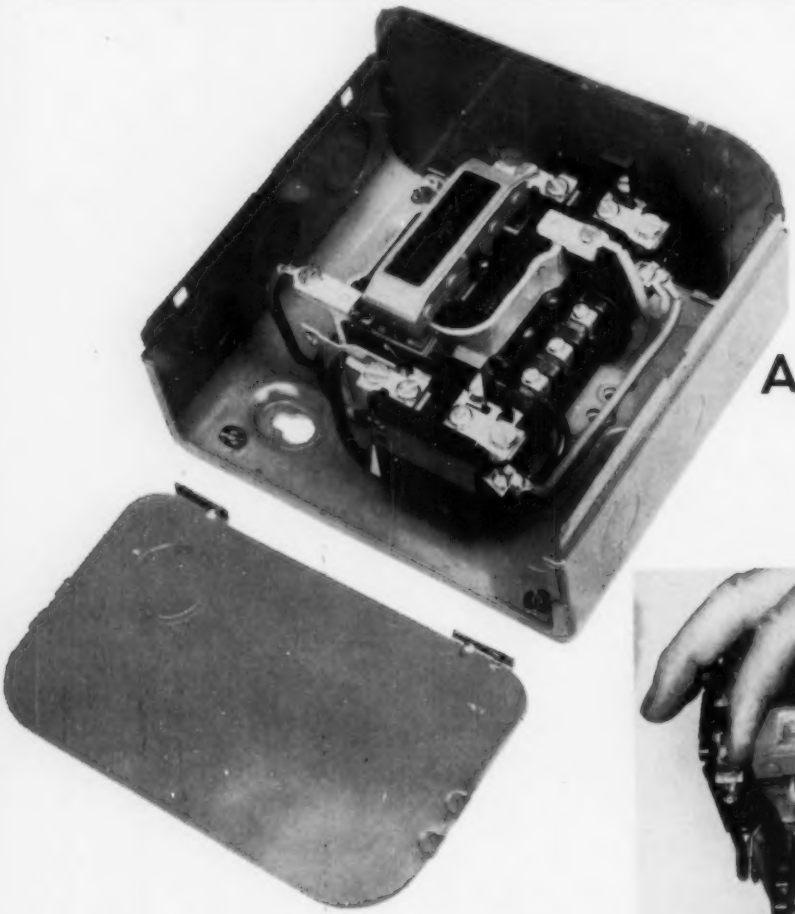
Power Capacity of Spur Gears *(Continued from page 217)*

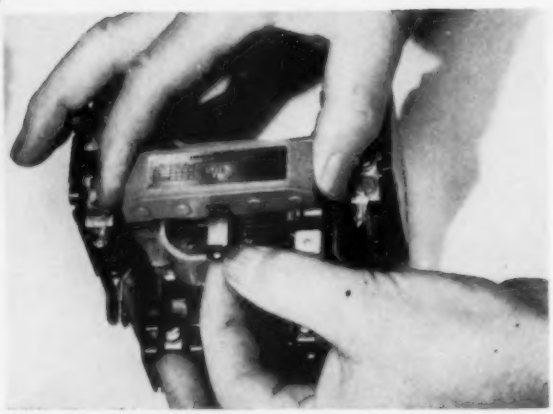
Surface Durability of Spur Gears. Based on AGMA 210.01 (1946)



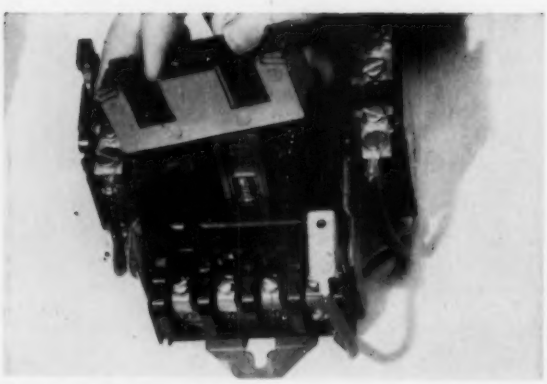
NEW COMPONENTS



Magnetic Motor Starters Are 42% Smaller



1 Principal components snap or slide apart. Here, the spring clip is being removed, releasing armature from contact arm . . .



4 The E-shape magnet structure slides out. Floating design and non-rigid assembly contribute to quiet pickup and operation . . . . .

5 Arc chute cover, which resists arcs and reduces carbon formation, lifts out. Stationary contacts can be inspected without tools . . . . .

AND MATERIALS

SPECIFIED BY PRODUCT ENGINEERS

Magnetic motor starters, rated 0 and 1 for 1 to 10 hp motors, built to new NEMA ratings ("New NEMA Standards for Motor Starters," Product Engineering, June 1957, page 189), are 42% smaller by area than previous open units. Various models of the basic unit operate as contactors or as full-voltage starters of the non-reversing and reversing types, or a combination of the two and also as multi-speed motor controllers.

Starters measure $4\frac{1}{2}$ x $5\frac{3}{32}$ in. and weigh 3 lb (50% less). Enclosed, they offer 32% additional wiring room and weigh 6 lb, a saving of 25% over other enclosed forms. The enclosed form is $7\frac{1}{4}$ x $6\frac{1}{2}$ x $4\frac{5}{8}$ in. The enclosure cover wraps around from top to bottom for greater accessibility. It is held to the starter with a spring-clip latch. Enclosure sides can be removed by loosening two screws.

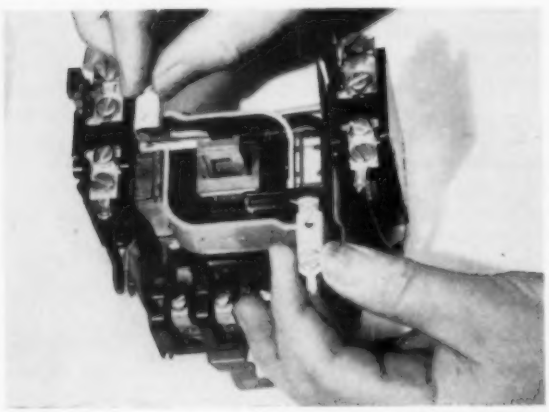
Size 0 units are rated to 5 hp at 440 v; size 1 units are rated for 10 hp at 440 v.

"Snap-slide" construction permits rapid and complete dissassembly, without tools, for inspection and maintenance. Principal components are constructed to snap or slide together.

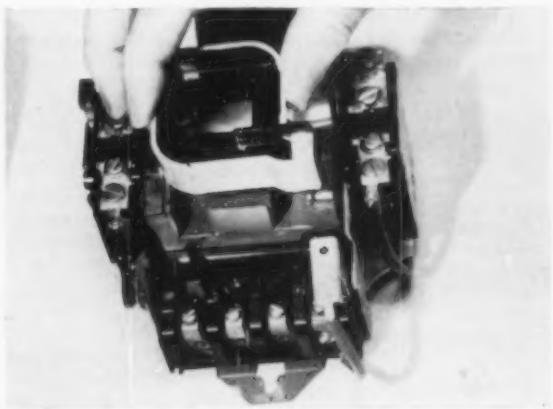
Use of a coil that requires a lower inrush current permits a reduction in cost and mounting space requirements for a control transformer. The solenoid coil, removable from the front, makes possible the use of a 47% lower rated transformer than with previous units. Since the coil is removed from the front, new starters can be mounted closer together on a panel.

Mounting of the starters can be in any position. Baseplate has three keyhole slots to facilitate mounting. The overload trip setting can be adjusted up to ± 15% of nominal heater rating by turning a knob on each of two relays. Long-life kick-off spring provides a quick, clean break of contacts in any

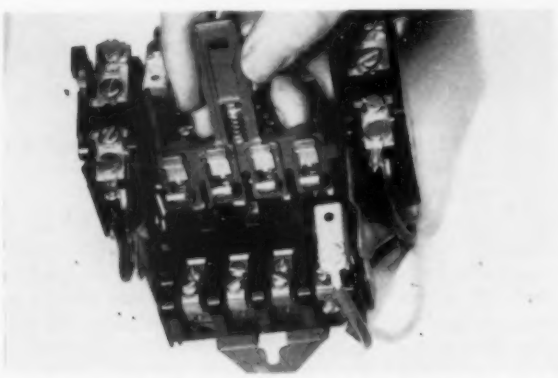
(Continued on page 349)



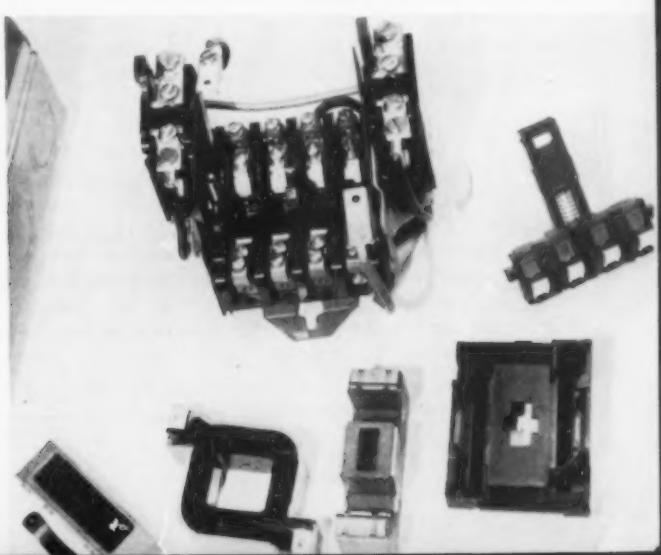
2 Specially designed coil terminal connections unclip without the use of tools. The coil can then be lifted from the unit . . . . .



3 Wiring is not disturbed during coil removal because of these connections. Coil construction resists dirt, oil, damage . . . . .



6 Contact arm slides out. Contacts are designed to give higher tip pressure, current rating. Horizontal action reduces bounce . . . . .



7 Dismantled components are shown with the base support. Snap-slide construction simplifies inspection and maintenance.

mounting position.

Straight-through wiring speeds installation and wiring is also simplified by pressure-type terminals. Ten combination knockouts are provided.

Closer tolerances in grinding the solenoid faces and the non-rigid magnet assembly contribute to quiet pick-up and operation of the starter. The magnet core uses an E-and-I shape.

These new starters are the result of continued improvement in hot and cold molded contact housing and support materials, in contact material and design, in reduced contact arcing, and in improved methods for closing higher currents and carrying them continuously without freezing.

Nine field modification kits, three of them new, make the starters even more versatile. One kit is for mounting an indication light in the enclosure cover; another is for adding an auxiliary pole in the field, and a third is an adaptor plate.

The starters have been developed for use with machine tools, pumps, compressors, hoists, fans, mixers and in motor control centers. General Electric, Schenectady 5, N. Y.

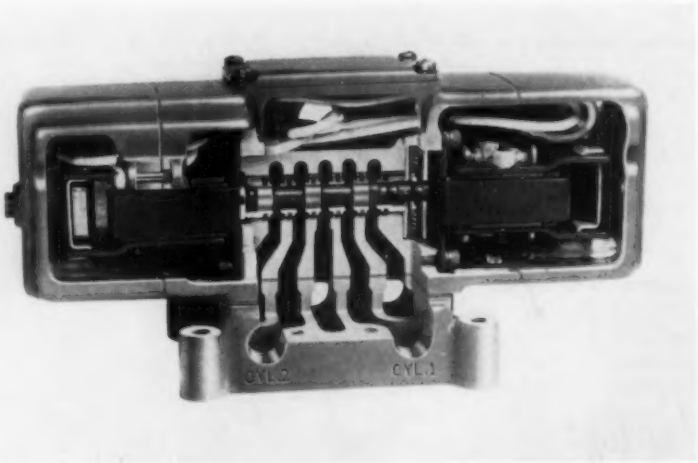
For more information—
Circle 1, inside back cover

Pneumatic Directional Control Valves

In this series of four-way directional control valves, the spool is shifted directly by the solenoid. Valves operate at pressures up to 250 psi, opening fully and establishing an air flow in about ¾ of one electrical cycle (11 millisec).

These lapped spool units are said to out-wear O-rings or seals and running friction is unaffected by pressure. The lapped lands of the spool seal equally well in both directions, and so are suitable for pressure and vacuum. The spool and sleeve are both chromium-bearing stainless steel.

The valves will run at −5 F and on hot water at 205 F without binding. In actual service, the fluid surrounds the spool and the sleeve, keeping both



at the same temperature to expand and contract together.

Single bases are available with either side or bottom ports. The bottom port base can be counter-bored for O-ring seals instead of being tapped, for mounting on the customer's manifold or threadless sub-plates. These valves can also be mounted on this manufacturer's manifolds.

All pipe threads in the new valve series are dry-seal, tapped a little shallow to allow for metal flow with repeated disassembly. Pressure ports are spaced wide enough apart to swing a JIC tube elbow without interference. Electrical connections are located in the top of the body to cut down width. On the double-solenoid models, a side location is provided, because the connection is in the narrow part of the valve body. The sleeves are a slip fit in the body and can be removed by pushing them out. Symmetrical, they can be installed either way.

The lapped spool design has low friction. In the momentary contact version, a double ball detent locks the spool in either position. This detent is strong enough to hold the spool and the upper solenoid plunger when the valve is mounted vertically. The ball detent consists of a pair of opposed balls and springs to balance each other and remove any side thrust on the plunger. Balls and springs, mounted in brass disk, are held in place by a spring clip or keeper ring that snaps into a peripheral groove in the housing. The entire assembly is handled as one piece.

The solenoid C-frame, mounted on a block of rubber, is held to the baseplate by a flexible spring clip, to dissipate the shock of the plunger seating. Likewise, the stainless steel bridge across the top of the frame, which takes the shock of stopping the plunger on the return stroke, is mounted in two rubber shock absorbers. Heat-resistant coils have magnet wire windings insulated with silicone enamel.

Coils are available in 60, 50, and 25 cps, from 24 to 550 v. D-c solenoids are also available.

All valves in the SA Series are full pipe size. The new valves are offered in modified form for hydraulics, up to 250 psi, and in ¼ and ⅜ in. sizes in single-pilot, spring-return and double-pilot models. Numatics, Inc., Milford, Mich.

For more information—
Circle 2, inside back cover

Filters Have Simplified Drain Mechanisms

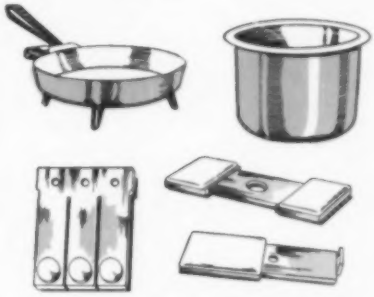
Automatic-drain air line filters have simplified drain mechanism with fewer parts and increased filtering efficiency. Filters operate effectively at air line pressures as low as 5 psi and as high as 150 psi for the trans-

CONTINUED ON PAGE 224

NEW BRIDGEPORT METAL LAMINATES

Offer Design and Production Opportunities No Single Metal Provides

Inside and outside story of metal laminates, their range of applications and properties.

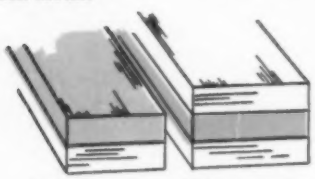


Typical applications include copper/stainless electric frying pans, heat exchanger tube sheets, salt pots, electric terminal strips and contact parts.

BRIDGEPORT METAL LAMINATES open up entirely new concepts in product design and application. Made up of layers of two or three dissimilar metals, metallurgically bonded, they can provide a combination of chemical, physical and mechanical properties that would be impossible to obtain with a single metal.

A Metallurgical "Sandwich"

Layers of metals are combined in either Duplex or Triplex form and are held together permanently by means of a specially developed braze-type bond. This bond has exceptional shear strength. There is no peeling, cracking or chipping, even in thin laminations. Furthermore, because it is a true metallurgical bond that joins the component materials, better use can be made of the individual physical properties of each metal.



Duplex Laminates **Triplex Laminates**
Metallurgical banding makes a laminate a "one-piece" metal with multi-metal characteristics.

Many Uses

A variety of metals can be formed into Bridgeport laminates. Thus it is possible to develop an almost unlimited variety of properties with different metal combinations. Some of the jobs, for instance, that can be performed are in:

1. Solving dual corrosion problems
2. Improving electrical and thermal conductivity
3. Combining high thermal conductivity with corrosion resistance
4. Obtaining greater strength-to-weight ratios in combination with other specific properties, such as conductivity or corrosion resistance.

Typical metals that can be combined are copper, brass, stainless steel, Muntz Metal, monel, mild steel, iron and the precious metals. Other combinations are possible.

Advantages

In addition to offering a wide range of desirable characteristics, Bridgeport Laminates offer unusual design and production economies. They are easily formed and joined. They can be furnished in desired shapes and formed to size, thus replacing forgings which would involve high machining costs.

In many instances, too, a thin sheet of relatively expensive material laminated with a thick sheet of less costly metal is more economical than a thick sheet of the more expensive material.

Properties Can Be Varied

Laminate properties are "tailor-made" and depend on the combination of metals used. However, some of the general characteristics can be stated.

Copper/Stainless Steel Laminates Offer Many Desirable Characteristics

Copper/stainless steel laminates have excellent heat transfer properties, high structural strength, are non-magnetic and have no appreciable thermostatic action to cause warpage or distortion. Likewise, their corrosion resistance is high, especially in applications where dual corrosion problems exist.

Heat exchanger tube sheet. 2 in. ASTM A-201 Gr. A firebox plate. 3/8 in. naval brass.

The strength of an individual laminate combination approximates the average strength of each of the bonded metals, depending on the amount of each metal in the laminate.

Thermal conductivity is based on the same conditions.

Ductility depends on the metals used. The laminates are usually furnished in the annealed condition, ready for forming. Surface finishes are not permanently affected by laminating.

Types, Sizes

In Duplex Laminates, either component can vary in thickness from .010 to 2 inches. They are made in sizes up to 30 inches square and, in many cases, even larger.

Triplex Laminates vary in component thickness from approximately .015 to 2 inches.

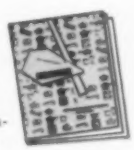
Samples

Test samples of Bridgeport Metal Laminates for development work are available through all Bridgeport Sales Offices. Specifically, copper/stainless Duplex Laminates and stainless/copper/stainless Triplex Laminates are immediately on hand and special combinations can readily be furnished.

Engineering Assistance

The design and manufacturing possibilities for Bridgeport Laminates are extremely flexible and offer virtually unlimited advantages. Bridgeport's long experience in the laminate field can be of decided benefit to you. We will be glad to furnish you with detailed technical assistance on any specific problem. Call your nearest Bridgeport office for full details.

Free Laminates Brochure
Bridgeport Metal Laminates, their properties, applications, types, sizes, are described in an 8-page technical publication. Write for your copy today.



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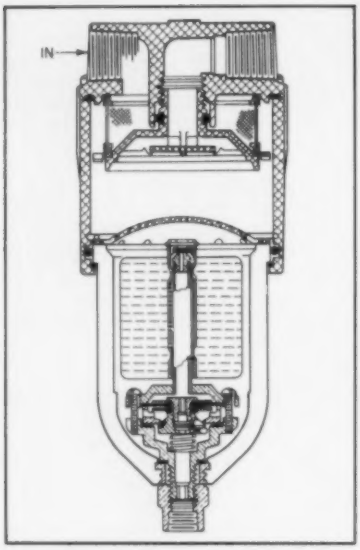
Bridgeport Brass Company, Bridgeport 2, Connecticut
In Canada: Noranda Copper and Brass Limited, Montreal

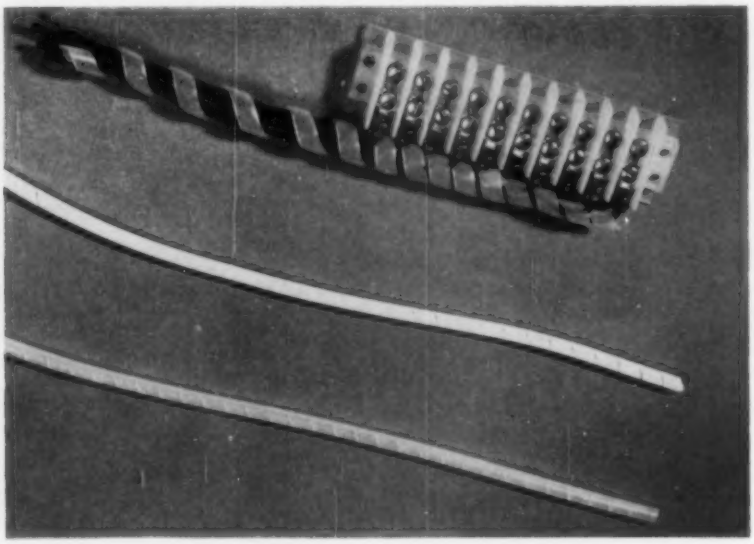


parent bowl models. Float-controlled, pilot-operated drain mechanism discharges only when collected liquid reaches full capacity. As long as there is pressure on the air system, they drain automatically.

Moisture and oil emulsions are removed at greater efficiency at air flows 143% higher than before. Louvers improve the centrifugal action of entering air. Three interchangeable filter elements are available.

Also, metal bowl filters have been added in ¼, ⅜, and ½-in. sizes. They extend the operating range to 200F and to 250 psi. C. A. Norgren Co., 3400 S. Elati St., Englewood, Colo.

For more information—
Circle 3, inside back cover



Spiral Plastic Wrapping Is Versatile Wire Binder

A spirally cut polyethylene wrapping that eliminates cable lacing, insulation damage, and pulling of wires through spaghetti tubing is available for both prototype and production cabling.

It is quickly applied to wire bundles up to 2 in. dia, at present. Other sizes are scheduled to apply to wire bundles from 0.093 to 3.50 in. dia. Individual wires can be entered or led out at any point and wires can be added, relocated, or taken out by unwinding. Plastic wrapping eliminates stocking of binding twine and several sizes of spaghetti. It is said to provide full protection for wires and allows the use of cable clamps without damaging critical insulation.

The translucent version is shown in use with a terminal board manufactured by Kulka Electric Co. White wrapping, center, has an additive to make it fire retardant. Wrappings are furnished cut to length or in reels. AMP, Inc., Harrisburg, Pa.

For more information—
Circle 4, inside back cover

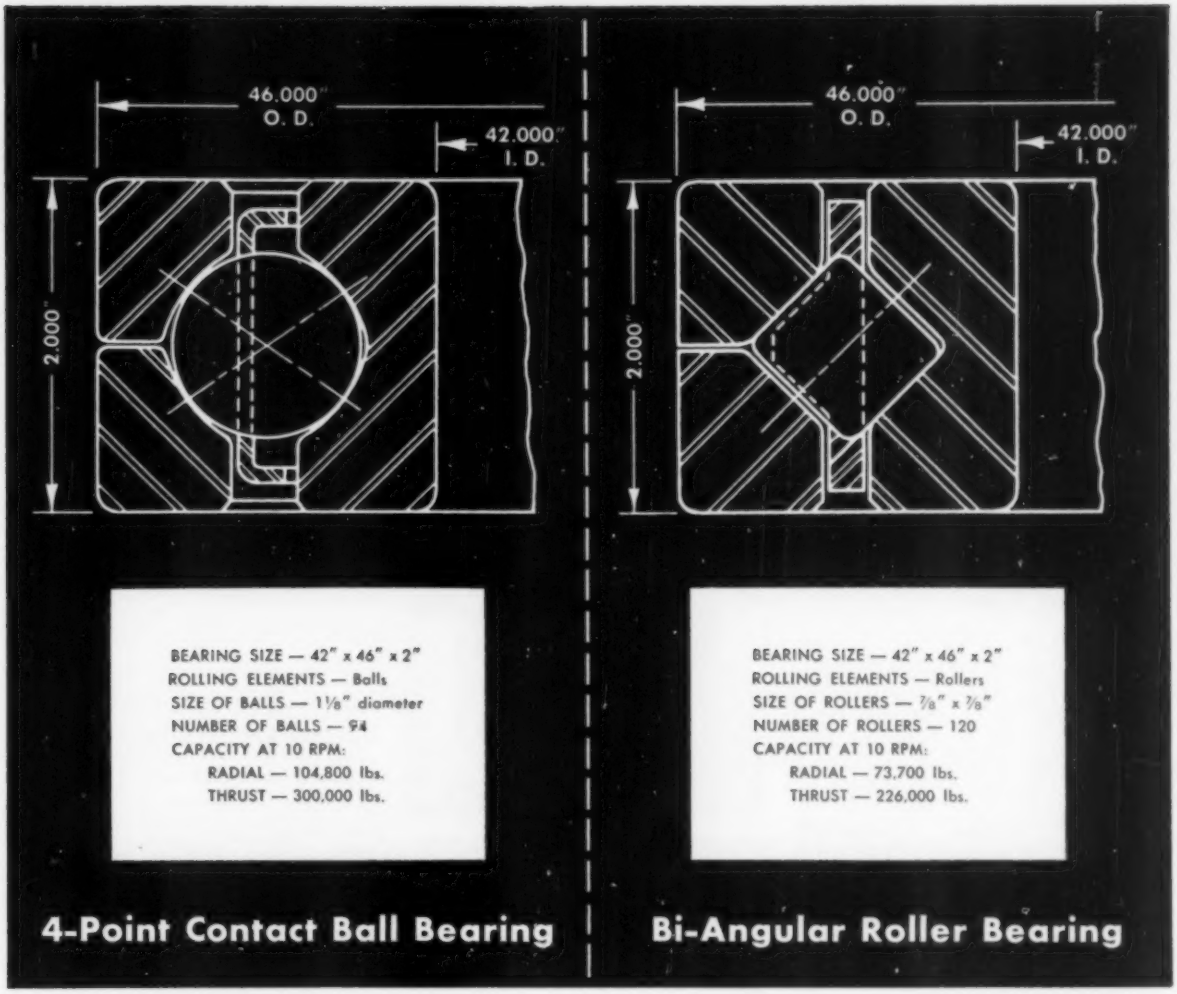
Fist-sized Electro-mechanical Counter

An electro-mechanical counter with a life of 300 million counts, count rate up to 60 per sec, either electrically or manually reset by a single-stroke push bar, and a switch readout circuitry which makes possible accurate programming, has been announced. The unit adds, subtracts, and totalizes. In the latter operation, it operates best with a counting pulse ratio of 50% on, 50% off.

It permits indexing through six digits. It is the size of a fist, incorporating the latest in electrical miniaturization, and uses etched circuitry. Bi-directional stepping mechanism is engineered so that it is locked between impulses. In four models. Autron Engineering, 1254 W. Sixth St., Los Angeles, Calif.

For more information—
Circle 5, inside back cover

CONTINUED ON PAGE 226



SURE we make both, but we recommend only one

Yes, Kaydon manufactures both — 4-point contact ball and bi-angular roller bearings in the same diameters and widths. BUT—we would in almost every instance recommend the former. Why? Because our field application reports consistently prove that the 4-point contact ball bearings are better for most applications than the lower capacity bi-angulars *(See capacity figures in drawings above.)*

Another important difference between the two bearings is that the 4-point contact ball bearing *is not limited to low speeds*, whereas the bi-angular normally should not be used above 10 rpm and usually is suitable only for oscillation. Then, too, the torque in the 4-point contact ball bearings is generally much lower.

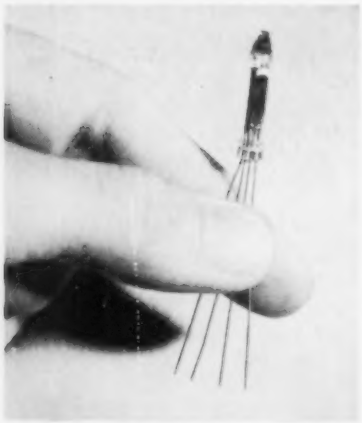
Kaydon's unbiased recommendations result from years of bearing design, application and manufacturing experience with *all types* of ball and roller bearings up to 124" in diameter. So, why not contact Kaydon first?

K-563

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

All types of ball and roller bearings — 4" to 120" outside diameter . . .
Taper Roller • Roller Thrust • Roller Radial • Bi-Angular Roller • Needle Roller • Ball Radial • Ball Thrust Bearings.



Subminiature Indicator Tube

This filament, high-vacuum, subminiature indicator triode, with a fluorescent anode, has been designed for applications in electronic computers and business machines where it can replace neon lamps. Can monitor transistorized circuits without loading the circuit. Gives bright blue-green indication when the control grid is at zero potential.

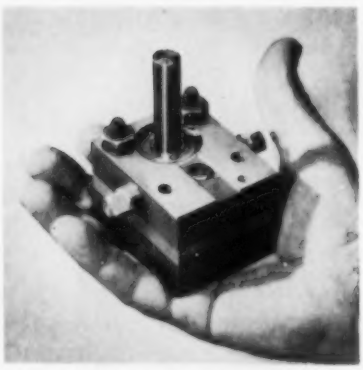
Designed for 20,000 hr life. Heater voltage is 1 v, 30 ma, a-c or d-c. Anode will draw 0.5 ma from a 50 v d-c supply during zero basis "on" condition. A 3.0 v d-c voltage cuts off plate current and light. Amperex Electronic Corp., 230 Duffy Ave., Hicksville, L. I., N. Y.

For more information—
Circle 6, inside back cover

Photoelectric Shaft Position Encoder

A photoelectric shaft position encoder that provides angular position data in cyclic binary code to an accuracy of 13 digits or better than 3 min of arc. It includes a 13-channel transistor preamplifier, each channel encapsulated separately. The unit may be used wherever it is desired to read a shaft position in digital form either to record such position on magnetic or punched tape or to apply it to a digital computer. Adcon, Inc., 1117 Commonwealth Ave., Boston 15, Mass.

For more information—
Circle 7, inside back cover



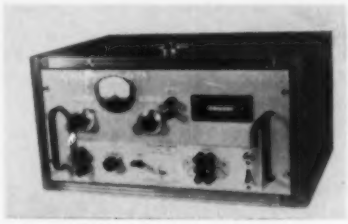
Hydraulic Gear-type Pump

A compact, wet-sump hydraulic gear-type pump for applications requiring a pump with a rated capacity of 0.5 gpm at 1000 psi at 1800 rpm. This pump, the Detroit 1000, contains hardened steel and bronze gears, the latter ball-bearing mounted. All wearing surfaces are hard-chrome plated. Though initially produced for use within the reservoir, sealed adaptations for mounting externally have been made. Detroit Testing Machine Co., 9390 Grinnell Ave., Detroit 13, Mich.

For more information—
Circle 8, inside back cover

Automatic Control of Test Limits

This programmer counter turns test apparatus on and off, where limits are sensed by strain gages, thermocouples, or other transducers that have a maximum output not exceeding 100 mv d-c. Unit eliminates the need for manual control of test cycling and simplifies the setting up of

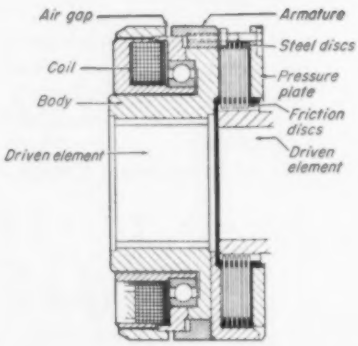


equipment each time a test is to be made. This relay has adjustable energizing and release thresholds and double-pole, double throw 15 amp contacts. The instrument operates on 110 v a-c. A flashing light or ringing bell signal can be supplied to indicate when the counter is registering. Spar Engineering & Development, Inc., Wyncote, Pa.

For more information—
Circle 9, inside back cover

Magnetic Clutch Provides Torque Control

A fast magnetic clutch that provides complete torque control under rated conditions is available in a range of bore sizes. Patented design features include comparatively short axial, small radial dimensions, complete isolation of the magnetic as-



CONTINUED ON PAGE 228

USING

DU PONT ELASTOMERS

neoprene · Hypalon®

in design

New NEOPRENE closure strip weatherproofs corrugated roofing and siding

Tire sidewall of HYPALON® stays white, resists sunlight, ozone

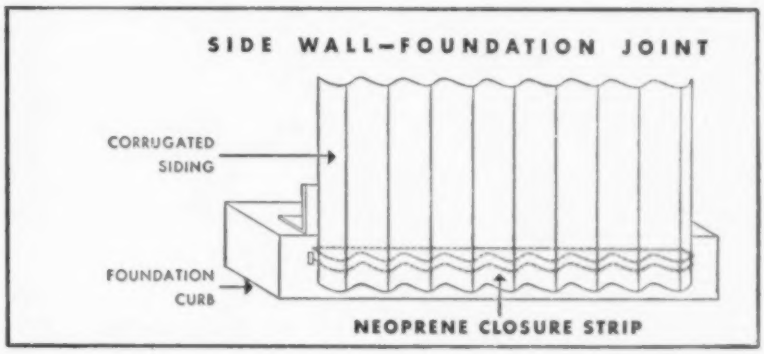
A leading tire manufacturer has greatly improved the appearance and performance of whitewall tires by using a special rubber compound which includes a substantial amount of HYPALON, Du Pont's new synthetic rubber. Road tests in the Los Angeles area show that the inclusion of HYPALON keeps the sidewall from cracking and becoming discolored.

Chief reason for this success is the outdoor stability of HYPALON. Minute traces of ozone in the air are the primary cause of whitewall deterioration, but HYPALON is *completely unaffected by ozone*. It also withstands sunlight, weathering and discoloration far better than other kinds of rubber.

Idea for extra-long service

HYPALON also has many other properties of interest to designers. It shows unusual resistance to hardening at elevated temperatures (250°-350°F.) and has excellent resistance to solvents and chemicals, including strong oxidizing agents. These properties make HYPALON a wise choice for use in many industrial products, such as gaskets, molded parts, diaphragms, belt, hose—any resilient product that must give long cost-saving service where service conditions are severe. Just clip coupon for more information about HYPALON.

Lasting whiteness for sidewalls is now a reality with HYPALON. This versatile synthetic rubber can also be compounded in an unlimited range of light-fast colors.



(Above) Diagram shows position of neoprene closure strip on side wall. (Left) Close-up shows manner of bolting neoprene strip to flashing section.

Elastic strip withstands temperature extremes . . . eliminates caulking

A new neoprene closure strip has been developed which, according to the manufacturer, will solve the problem of weatherproofing corrugated roofing and siding. Only an inch wide, this non-porous closed-cell neoprene closure strip is die-cut to fit corrugations, forming a snug seal. Neoprene's long service life assures lasting protection for a building's exterior from dust, dirt, water and air—at minimum maintenance.

The closure strips are installed on roofing under the aprons of ridge roll and under flashing sections at roof junctions and side walls. They're fastened at the same time as the corrugated sheeting. No separate caulking is required.

Neoprene's elasticity and lasting resistance to weathering, temperature extremes and aging are vital to the success of the closure design. The strip *stays* elastic, won't become brittle and then crack in cold weather or become soft and sticky in hot weather. You may find just the properties your designs need in neoprene, Du Pont's versatile synthetic rubber. For more information, just clip the coupon.

Hundreds of feet of neoprene closure stripping are used at roof, side wall, window and door junctures of this typical building.

DU PONT

REG. U.S. PAT. OFF.

HYPALON *is a registered trademark of E. I. du Pont de Nemours & Co. (Inc.)*

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

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E. I. du Pont de Nemours & Co. (Inc.)
Elastomer Chemicals Dept. PE-8
Wilmington 98, Delaware

*Name*_____
*Firm*_____
*Address*_____
*City*_____ *State*_____

sembly from the integral mechanical parts, and compact, precision assembly of all component parts. Furnished in stationary or brush types and for wet or dry operation. The self-contained unit has high heat-dissipation characteristics. Fawick Airflex Div., Fawick Corp., 9919 Clinton Rd., Cleveland 11, Ohio.

For more information—
Circle 10, inside back cover

Miniature Hydraulic Cylinders

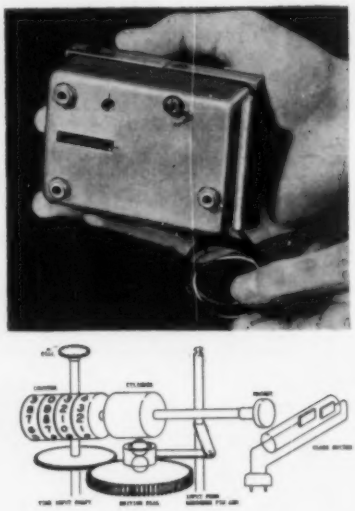
Hydraulic clyinders in five bore diameters, ½, ¾, 1, 1¼, and 1½ in., have stroke lengths to 36 in. All except the ½-in. size are offered with standard or 2:1 rod. Rated at 3000 psi continuous service, with peaks up to 10,000 psi.

These non-cushioned cylinders may be used for actuation on many smaller products and will conserve valuable space when used on larger products. Telescopic-type and pneumatic cylinders are also available in these miniature sizes. Oil-Dyne, Inc., 2115Z W. Marquette Rd., Chicago 36, Ill.

For more information—
Circle 11, inside back cover

Integrates or Averages Shaft Position, Displacement

This linear integrator can be used to provide continuous integration in any instrument or system where integration, area or average computations, and a direct or remote read-



SCHEMATIC OF LIBRASCOPE LINEAR INTEGRATOR

ing is required. The integrator is a ball and disk mechanism, assembled with a counter and an output pulse switch. It can be adapted to strip chart recorders of various types and sizes, and can be used wherever the variable to be integrated or averaged is presented as a shaft position or displacement.

In handling an input, a time motor drives a disk, which in turn imparts rotation to a cylinder through two steel balls. The counter and magnet for actuating the pulse are mounted directly on the cylinder shaft. Steel balls rotate in a carriage that is positioned by the input shaft through an arm and a connecting link. Thus, if the motor drives the disk at a constant speed, the cylinder will turn at a rate proportional to the degree of rotation of the input shaft.

As the measured variable changes, this motion positions the ball-carriage so that the counter-speed will be proportional to the integral of this variable with respect to time or the time-input function. The counter will then read the result of this computation over the period between readings. The output pulse can be used to transmit this reading to a remote counter or recorder.

Applications for this integrator include flow totalization, averaging of temperature and pressure values, and area computation in gas analysis procedures. Librascope, Inc., 808 Western Ave., Glendale, Calif.

For more information—
Circle 12, inside back cover

Miniature Magnetic Clutch

A single end concentric shaft magnetic clutch brake for application to low power servomechanisms. It can be wound to operate on from 1.5 to 300 v d-c. The unit delivers a minimum of 8 in.-oz. of clutching and braking torque. Response is as low as 3 millisec. Angular displacement error upon engagement is three to seven min of angle. Power consumption is 3 w. Mounting OD is 1⅞-in. Dynamic Instrument Corp., 59 New York Ave., Westbury, N. Y.

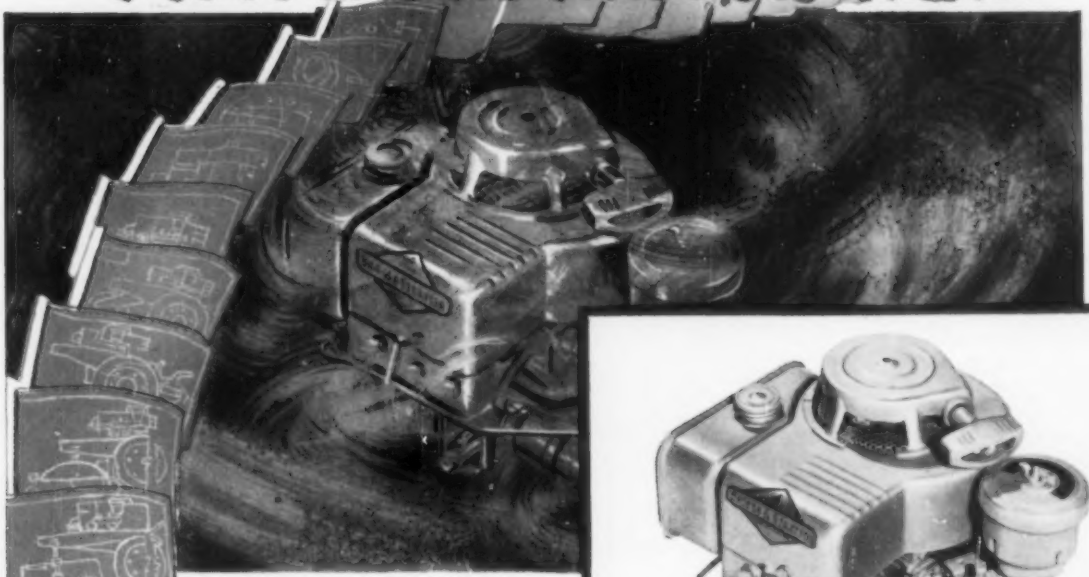
For more information—
Circle 13, inside back cover

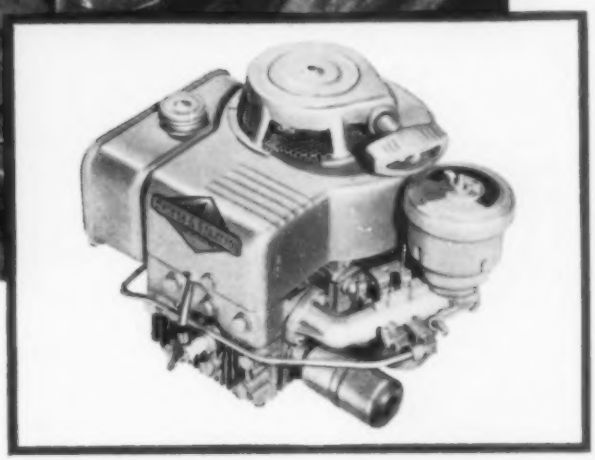
Shunt, Relay Style Circuit Breakers

Shunt and relay-style circuit breakers use the same magnetic time-delay trip mechanism as series-style breakers. Trip level is independent of temperature. In series-style breakers, the release coil is in series with the contacts and operates when the load

CONTINUED ON PAGE 230

Man-made dust storms...*





* GRUELING, ACCELERATED TESTS THAT PROVE ENGINE PERFORMANCE

In these dust pit tests, engines receive regular maintenance (more frequently performed) yet operate where men would suffocate.

Why Briggs & Stratton engines deserve your design-decisions

Stringent, never-ending quality control is an important factor in translating superior designs into superior engines. And when it comes to quality control at Briggs & Stratton, nothing is left to chance.

The torture test above is only one of many methods employed to "prove out" Briggs & Stratton 4-CYCLE engines — from design, materials and actual performance standpoints. It's added evidence why Briggs & Stratton 4-CYCLE engines (to 9 hp) deserve your design-decisions . . . why they're *No. 1 in use throughout the world.*

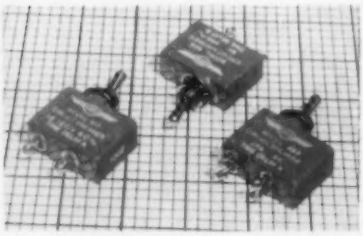
Write now for details on the Briggs & Stratton line.

4 CYCLE
BRIGGS & STRATTON
GASOLINE ENGINES ®

Find Us Fast In The Yellow Pages

— represented by a world-wide network of more than 9000 authorized engine service outlets.

BRIGGS & STRATTON CORP.
Milwaukee 1, Wisconsin

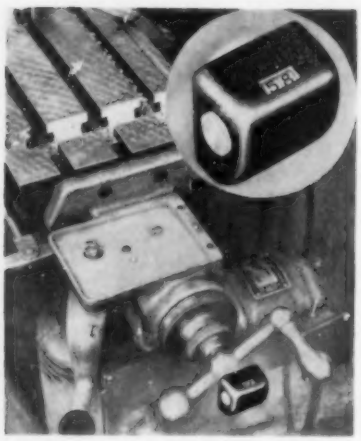


current exceeds 135% of normal rating. In shunt-style breakers, the release coil can be shunted externally by a rheostat to adjust trip level. In relay-style breakers, the release coil is entirely independent of the contacts.

These hermetically sealed breakers withstand 50 G shock, vibrations of 10 G to 1000 cps and operate from −67F to 212F. Contacts are rated for 50 v d-c or 120 v rms at 60 or 400 cps, up to 10 amp. Airpax Products Co., Ft. Lauderdale, Fla.

For more information—
Circle 14, inside back cover

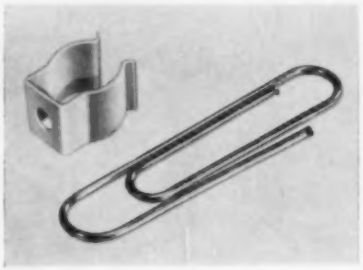
ELECTRICAL POWER, CONTROL



Lead Screw Revolution Counter

A revolution counter for all types of milling machines and other machines can be used where a cumulative count of lead-screw turns is desired. This instrument records the exact number of desired lead-screw turns, eliminating human counting errors. Made in various thread sizes to fit any special lead-screw handle bolts. Pacific Transducer Corp., 11836 W. Pico Blvd., Los Angeles 64, Calif.

For more information—
Circle 15, inside back cover



Transistor Clip Dissipates Heat

A transistor clip retains popularly used transistors under conditions of severe acceleration, deceleration, shock, and vibration. Made from tempered berylium copper, the clips also act as heat dissipators. Offered in a choice of cadmium, black ebanol, or silver plate in various sizes and modifications. Birtcher Corp., 4371 Valley Blvd., Los Angeles 32, Calif.

For more information—
Circle 16, inside back cover

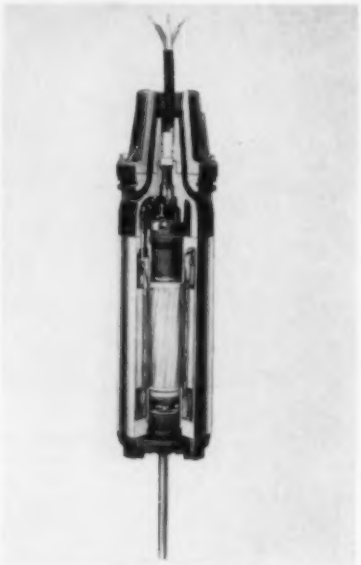
Throttle Control for Power Take-offs

This hydraulic throttle control can be installed on any engine providing proper speed for load lifting, and only for the actual period of lifting. This is said to eliminate setting engines ahead and to reduce clutch wear and fuel consumption. It is adjustable and works with any hydraulic pressure system.

The control measures 5 in. long and weighs 1½ lb. The device needs no lubrication or spring changes for continuous operation.

Pressure from the power take-off's pump or equivalent automatically actuates the piston in the control. As the pressure increases to lift a load, the piston increases engine speed. The throttle control automatically returns the engine to idling speed. Stratton Equipment Co., 2030 E. 105 St., Cleveland 6, Ohio.

For more information—
Circle 17, inside back cover



Submersible Motors

Electric motors, ⅓ to ¾ hp, that operate fully submerged in gasoline, fuels, oils and other liquids are lubricated and cooled by the liquid in which they are submerged. Electrical connections consist of a three-lead cable entering the motor through a sealed connector.

Above the liquid level, the cable enters a control box that may contain a starting capacitor, relay and overload protector. A terminal board for connections to fuel dispensers or switch stations is in the control box. Submersible motor windings are embedded in plastic and hermetically sealed in a welded stainless steel case. Franklin Electric Co., Bluffton, Ind.

For more information—
Circle 18, inside back cover

Reinforced Conductor

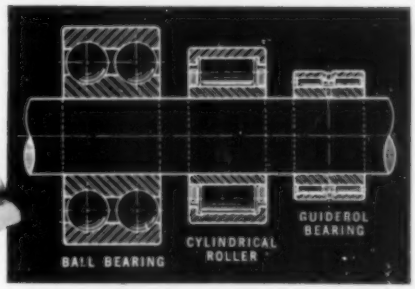
A mechanically improved electrical conductor has a higher breaking strength and high resistance to flexure fatigue. In accordance with MIL-W-

CONTINUED ON PAGE 232

BEARING TIPS by McGill

To pack more performance in smaller space

Use space-saving McGILL GUIDEROL® needle bearings

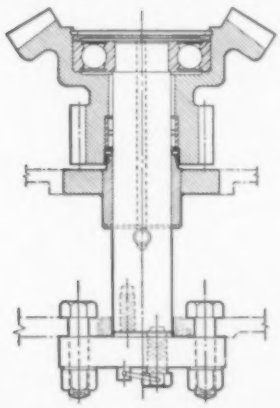


Showing graphically how a McGill GUIDEROL precision needle bearing permits more streamlined designing by supporting comparative loads in significantly smaller radial space than other types of bearings. Bulky and more costly housing space is easily avoided.

The McGill GUIDEROL Bearing combines the inherent high-load capacity of a full complement of full race width rollers with a center roller guiding principle that limits skewing and binding under misalignment. This qualifies the bearing for a whole range of applications that are too heavily loaded for a retainer-type bearing and are subject to the misalignment that precludes use of an ordinary needle bearing. For outstanding performance in small radial space, use GUIDEROL precision needle bearings. Specify the interchangeable sealed SGR series for added protection against contamination.

GUIDEROL® *bearing capacity, space economy proved in power shovel vertical reversing shaft assembly*

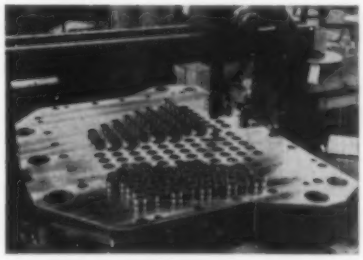
Baldwin - Lima - Hamilton Corp. uses a McGill GUIDEROL bearing, on ½ cubic yard power



shovels, to carry spur pinion loads in the vertical reversing shaft. The high capacity of the bearing in small radial space is an important factor in selection of this bearing. Only 3.75″ in diameter, it has a load capacity of 28,560 lbs. at 100 rpm. In the power shovel application, it supports 14,150 lbs. at 76.3 rpm, which gives a high margin of safety. The center guided rollers also are especially adaptable to a vertical application such as this.

Fact-packed Bearing Catalog

Write for your copy of Catalog #52-A, a 128 page Bearing Selection Guide. It contains vital product information and 30 pages of engineering data.



Multiple spindle drill heads require support of spindles on very close centers

Crowding a great number of drill spindles into a small area, Zagar, Inc., of Cleveland has found the McGill GUIDEROL bearing construction especially suited to the needs of multiple drill head units. The full bearing width rollers provide rigidity and more than adequate load capacity and in a bearing only 1.25″ in bore diameter.

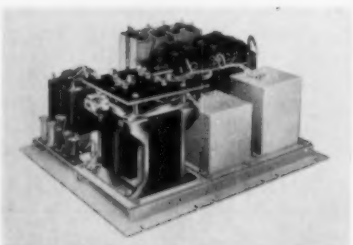
Insure performance with McGILL®

MULTIROL® GUIDEROL® CAMROL
Precision Needle Bearings

McGILL MANUFACTURING COMPANY, INC., 201 N. LAFAYETTE ST., VALPARAISO, INDIANA

16878, the center strand of silver-plated copper has been replaced with an equal-size strand of a special high-strength, non-magnetic alloy. The conductor permits airborn equipment manufacturers to reduce weight by changing to a smaller wire size. The slight increase in resistance characteristic of the new wire over standard all-copper conductors should not effect the electrical system, especially when short lengths, 100 ft or less, are used. Hitemp Wires, Inc., Mineola, N. Y.

For more information—
Circle 19, inside back cover



Automatic Voltage Regulator

Maintenance-free automatic voltage regulation is claimed for this unit. It has no tubes, transistors or moving parts. Designed to provide constant voltage despite line voltage or load changes. Input and output connections are made to the terminal board inside the cabinet.

Input is 95 to 135 v; output is 115 v nominal, adjustable from 110 to 120 v. Accuracy is 1 v band for line voltage variations and/or load magnitude and power factor changes. Waveform distortion is 4% max. Response time is less than ½ sec for ordinary line and/or load changes. Size is 21⅝ x 19 x 12⅝ in. Weight is 215 lb. Superior Electric Co., 83 Laurel St., Bristol, Conn.

For more information—
Circle 20, inside back cover

Thyratron Tube With 1 Amp Rating

A thyratron tube with a 1 amp average rating has been introduced. The tube is 3½ in. high. This grid-controlled rectifier has many applications in relays, inverters, and exciter regulators.

The tube has an octal base and top cap and a 10 v drop in use. Filament voltage and current is 5 v and 3 amp, respectively, with a heating time of 120 sec. Peak forward and inverse voltage are 500 v; d-c start (plus 3 v grid) is 25 v, with 25 v emission at 30 amp. De-ionization time is 200 microsec or less. Continental Electric Co., 6 N. Michigan Ave., Chicago 2, Ill.

For more information—
Circle 21, inside back cover

Transistor-Equipped Converter

This analog-to-digital and digital-to-analog converter is said to provide for voltage-to-digital and digital-to-voltage conversions at accuracies of better than 0.01% and speeds in excess of 15,000 ft per sec for analog-to-digital conversion and 300,000 per sec for digital-to-analog conversion. The device is asserted to be the first all-electronic device that permits multiplication and division in the process of conversion. Packard-Bell Computer Corp., 11766 W. Pico Blvd., Los Angeles 64, Calif.

For more information—
Circle 22, inside back cover

Transistor-Equipped Voltmeter

This dual-purpose instrument couples a d-c amplifier with a voltmeter of broad range. It has eight ranges from 30 mv to 100 v full scale and provides gains of 0.05 to 167 v. The line-operated instrument features 10^{14} ohm input impedance and uses balanced circuits to drive a three-stage push-pull transistor amplifier. Drift is less than 3 mv per hour after a 1 hr warm-up. Accuracy is within 2% of full scale.

This model 220 d-c vacuum tube voltmeter also has two separate outputs, ±5 v and ±1 amp to drive sensitive recorders, oscilloscopes and amplifiers. Keithley Instruments, Inc., 12415 Euclid Ave., Cleveland 6, Ohio.

For more information—
Circle 23, inside back cover

High-Temperature Connectors

Three series of miniature, high-temperature, electrical connectors with a staggered construction to give long creepage path between pins despite small dimensions have been announced. The body is aluminum, anodized for corrosion resistance. Each pin of the mated connector is sur-

CONTINUED ON PAGE 234

What every designer should know about

FACE GEARS for Angular Drives

FACE GEARS have distinct advantages which the designer should know. They can be spur or helical, "on-center" or "off-center." The mating members are pinions. Both are generated on Fellows Gear Shapers by cutters having involute teeth.

Utilization of face gears results in a simple, compact design that can be economically manufactured and assembled.

Consider all these advantages:

- quality cutting at low cost
- easier and lower cost assembly
- no appreciable thrust
- pairing for reversal of direction
- tooth bearing not affected by axial displacement of pinion

GET ALL THE FACTS:

Information on the design and cutting of Face Gears is free for the asking. Just write to:

THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont

Branch Offices:
1048 North Woodward Ave., Royal Oak, Mich.
150 West Pleasant Ave., Maywood, N. J.
5835 West North Avenue, Chicago 39
6214 West Manchester Ave., Los Angeles 45

THE PRECISION LINE **Fellows** *Gear Production Equipment*

rounded by Teflon. Three different types of receptacles and a matching plug to fit all three are available. Offered with 1, 3, 7 or 19 pins, the connectors are rated 1800 v a-c at sea level and 800 v a-c at 70,000 ft. They can withstand a shock of 200 G and show no resonance to 2000 cps. Operational temperature range is −67F to 400F Glendale Div., Consolidated Electrodynamics Corp., 740 Salem, Glendale, Calif.

For more information—
Circle 24, inside back cover

Printed Circuit Connectors

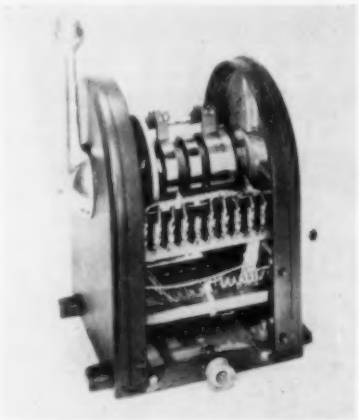
Printed circuit connectors are available in eight different sizes, with 6, 8, 10, 12, 15, 18, 22 and 38 contacts. Contacts are 0.058-in. wide coined beryllium copper, heat treated to retain contact force after hundreds of insertions. Barriers between terminals resist high voltage breakdown ratings, exceeding 2500 v rms at sea level and 700 v rms at 60,000 ft. Present models are for printed circuit board thicknesses from 0.061 to 0.071 in. Polarizing pins may be located in any slot desired. Materials and construction match specifications of Mil-C-8384. Gorn Electronics Div., Gorn Electric Co., Inc., 845 Main St., Stamford, Conn.

For more information—
Circle 25, inside back cover

Controller Has Long Life

A controller for use on variable voltage drive and power applications where speed or voltage can be manually or mechanically controlled through suitable linkage, and where the operation requires the continuous adjustment of the controller. Designed to serve for five years or more without replacement of any parts, according to the manufacturer.

It can be connected for either a rheostat or potentiometer circuit and can be designed to give any degree of handle movement to obtain full-speed control up to 300°. Up to 52 speed steps are available for non-reversing applications; 26 in each direction on reversing applications.



The unit has cast aluminum housing, class B insulated wire, standard resistors. Dimensions are 9 x 9 x 11 in. Republic Electric & Development Co., 2627 Western Ave., Seattle 1, Wash.

For more information—
Circle 26, inside back cover

Single Coil Induction Motor

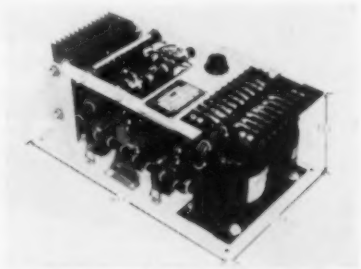
A single coil, two-pole induction motor is made in various stacks, from 1/300 to 1/50 hp. Free speed is 3400 rpm; load speed is 3000 rpm. The motor is designed for 115 v, 60 cps operation. A wide variety of applications includes operation of movie projectors, fans, gear motors and pumps. Heinze Electric Co., 685 Lawrence St., Lowell, Mass.

For more information—
Circle 27, inside back cover

Voltage Regulator Without Moving Parts

This voltage regulator maintains output voltage of 60-cps alternators. The regulator is a single-stage magnetic amplifier unit with selenium rectifiers and wire-wound resistors. It requires six terminal connections, and works into a 20 to 100 ohm exciter field without adjustment.

It supplies exciter field current within a range of 0.15 to 1.35 amp, and connects directly into any 208 or 240 v alternator without need of a potential transformer. When used with a 500 va potential transformer,

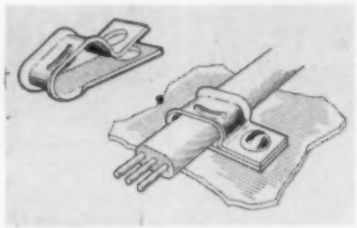


it operates with alternators of any output voltage. Vickers Electric Div., Vickers, Inc., 1815 Locust St., St. Louis 3, Mo.

For more information—
Circle 28, inside back cover

Clip for Electrical Wiring Strain Relief

This one-piece clamp has been developed for securing mid-rip cord in electrical appliances. UL-approved for



strain relief, the fastener is said to eliminate the need for extra parts and parts handling. Wire chafing is prevented by flanged edges and an embossed or dimpled leg permits the use of either the 115 or 230 v power cord. The clip can be used on any appliances that utilize a two or three-wire power cord, with $\frac{3}{16}$ x $\frac{7}{16}$ in. section. Tinnerman Products, Inc., Cleveland, Ohio.

For more information—
Circle 29, inside back cover

High Temperature Switch

A hermetically sealed miniature switch, weighing 1 oz, designed to operate continuously at temperatures as high as 375F, is available with screw or solder-type terminations. It is unaffected by shock as high as 200 G; vibration of 40 G, 0 to 500 cps. Current capacity is 10 amp at 75 F. The

CONTINUED ON PAGE 236

HOW MANY WAYS CAN *Special Purpose Fasteners* CUT COSTS FOR YOU?

How many of your products employ laborious, old-fashioned fastening methods where simple fasteners could do the job and cut costs, too? How many parts and sub-assemblies can be adapted to include a self-fastening feature? How many future products could be improved by advance planning for fastener efficiency?

United-Carr's engineering staff offers you a wealth of experience in the design of special-purpose fasteners and self-fastening devices. Large-scale manufacturing facilities (including in-plant plastics molding equipment) ensure economical, *volume* production and prompt deliveries. United-Carr field representatives are ready to call on you at *your* request.

POLYETHYLENE MOUNTING FOOT

No mar, no scratch glide for use on TV receivers, record changers, small appliances, etc. Assembles into round hole in wood or metal cabinets.

NYLON SNAP-IN NUT

Snaps into square hole stamped out of sheet metal . . . provides secure anchorage for any sheet metal or self-tapping screw . . . highly effective electrical insulator.

QUICKEY FASTENER

Eliminates need for welding or swaging studs to sheet metal stampings, facilitates nesting, eliminates damage in transit because Quickey snaps in before final assembly.

THREAD CUTTING FASTENER

Re-usable, self-locking, vibration-proof fastener cuts clean, deep threads on unthreaded chrome-plated studs. Available for $\frac{1}{4}$", $\frac{5}{16}$" and $\frac{1}{4}$" studs.

PLUG BUTTONS

Snap into $\frac{1}{8}$" to 3" dia. holes. Can be embossed with ornamental or functional designs . . . various finishes, shapes and sizes.

FISHTAIL RATCHET PLATE

Holds on smooth, die-cast metal or plastic studs to anchor name plates, trade marks etc. on appliances, automobiles, electronic apparatus, etc.

TRIMOUNT STUDS

Hold two or more thicknesses of material together. Easily installed by hand. Insure vibration proof attachment. Permanent or removable. Many shapes and sizes.

V-LOCK TEENUT

Re-usable, self-locking, one-piece, all-metal nut has high tensile strength, is unaffected by heat or oils. In various shapes, sizes and metals.

SOL-A-NUT

Self-locking, rustless, heat resistant. Sturdy, one-piece stainless steel construction prevents corrosion if nicked or scratched.

DURABLE DOT FASTENER

Snap fastener for cloth, leather, plastics and other materials. Positive closure, instant release. Black, nickel or brass finish.

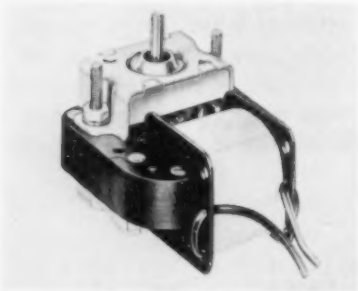
CARR FASTENER COMPANY

Division of United-Carr Fastener Corp., Cambridge 42, Massachusetts

MAKERS OF DOT FASTENERS

life expectancy of the switch is 25,000 cycles, minimum under rated load, higher under reduced load. Spencer Thermostat Div., Metals & Controls Corp., Attleboro, Mass.

For more information—
Circle 30, inside back cover



Self-Lubricating Shaded Pole Motor Has Longer Life

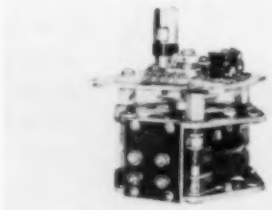
A shaded pole motor is available in 12 models. The bearing unit has acquired its name because of the ability of the packing to retain the lubricant almost indefinitely. The self-lubricating bearing functions even in elevated temperatures. Oil constantly feeds into bearing cavities as operating conditions demand.

The motor is suitable for applications where inaccessibility and hard use are prime factors. Standard mounting holes make it interchangeable with other motors. Controls Co. of America, 2450 N. 32 St., Milwaukee 45, Wis.

For more information—
Circle 31, inside back cover

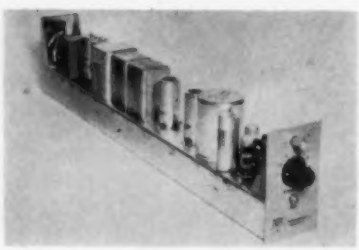
High Frequency Transformers

Variable transformers that deliver a continuously adjustable voltage from a-c power lines are available for single and three-phase, 400/800 cps operation. Manual and motor-driven air-cooled models for 28, 120, 240 and 480 v in ratings from 56 va to 8.7 kva are offered. Said to weigh ¼ as much and occupy ½ the cubic space as conventional 60 cps units. Engineered to operate at ambient temperatures of −55 C to 40 C at full-rated load



(reduced to 80 C); altitudes to 50,000 ft; up to 95% relative humidity; vibration, shock, inclination and corrosion resistance per military specifications. The Superior Electric Co., Dept. PH, 83 Laurel St., Bristol, Conn.

For more information—
Circle 32, inside back cover



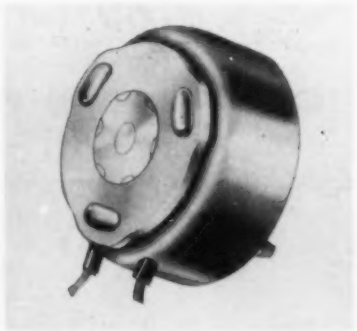
D-C Amplifier

The gain of this d-c amplifier, featuring a floating input, is continuously variable from 5 to 100 by means of a seven-position attenuator and a gain potentiometer. Linearity is 0.05% of full scale. Long-term stability is ±0.2% of full scale, and long-term drift is less than ±5 mv referred to the input. Input impedance is greater than 1.5 megohm and output impedance is 60 ohm. Noise level is less than 5 mv peak-to-peak referred to the input. The amplifier, basically a carrier type, uses a 400-cps chopper modulator. Neff Instrument Corp., 2211 E. Foothill Blvd., Pasadena, Calif.

For more information—
Circle 33, inside back cover

Rotary Solenoid

A rotary solenoid that can withstand ambient temperatures to 500 F has been developed. A life expectancy



of 300,000 snap-action operations at that temperature is claimed. It can also operate with higher wattage inputs to produce higher torques and for use in radioactive atmospheres. Eight basic sizes, from 1 to 3⅜ in. dia, with starting torques from 45° stroke range from 0.2 in.-lb to 54.0 in-lb are available. G. H. Leland, Inc., 123 Webster St., Dayton 2, Ohio.

For more information—
Circle 34, inside back cover

Magnetic Amplifier Regulator

A tubeless regulator is said to possess high transient overload capacity and adjustable output voltage. It is insensitive to frequency changes. The magnetic amplifier line regulator reduces weight of 1 kva unit to 40 lb. Output voltage is regulated from an input of 95 to 130 v, no-load to full-load. McHenry Control Corp., P. O. Box 604, Norwalk, Conn.

For more information—
Circle 35, inside back cover

Miniature Switches

A small, enclosed, push-button type switch is offered in behind panel and front mounting designs. Both are available in single-make, single-break, single-make-break or make-before-break

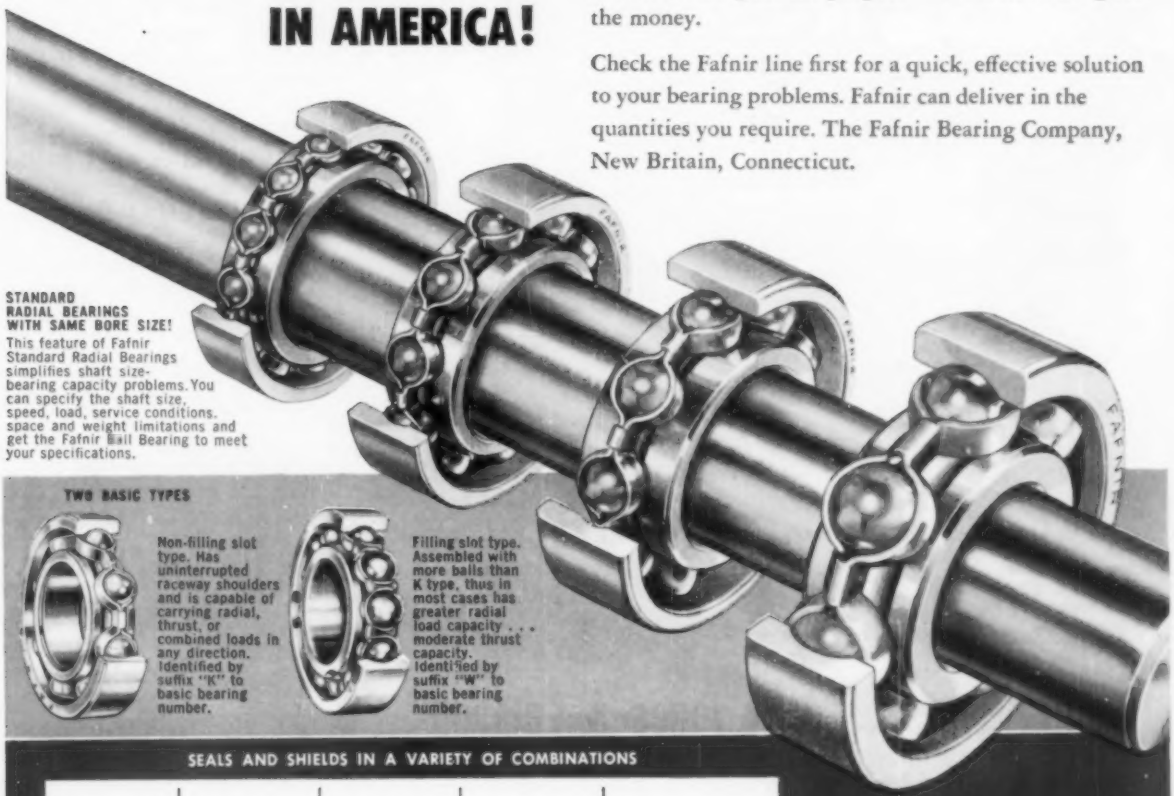
CONTINUED ON PAGE 238

For the most effective answers to your bearing problems...

FAFNIR OFFERS THE MOST COMPLETE LINE OF BALL BEARINGS IN AMERICA!

Whatever your bearing needs, your best bet is Fafnir. The reason . . . Fafnir makes America's most complete line of ball bearings, ranging from standard radial to custom-made jet engine types. Various tolerances and combinations of seals and shields enable Fafnir to supply the best bearing for the purpose — the *most* bearing for the money.

Check the Fafnir line first for a quick, effective solution to your bearing problems. Fafnir can deliver in the quantities you require. The Fafnir Bearing Company, New Britain, Connecticut.



STANDARD RADIAL BEARINGS WITH SAME BORE SIZE!
This feature of Fafnir Standard Radial Bearings simplifies shaft size-bearing capacity problems. You can specify the shaft size, speed, load, service conditions, space and weight limitations and get the Fafnir Ball Bearing to meet your specifications.

TWO BASIC TYPES

Non-filling slot type. Has uninterrupted raceway shoulders and is capable of carrying radial, thrust, or combined loads in any direction. Identified by suffix "K" to basic bearing number.

Filling slot type. Assembled with more balls than K type, thus in most cases has greater radial load capacity . . . moderate thrust capacity. Identified by suffix "W" to basic bearing number.

SEALS AND SHIELDS IN A VARIETY OF COMBINATIONS

1 Shield

1 Felt Seal and Shield

1 Mechani-Seal and Shield

1 Plya-Seal

Wide Type Bearing with Plya-Seals

2 Shields

2 Felt Seals

2 Mechani-Seals

2 Plya-Seals

Wide Type Bearing with Mechani-Seals

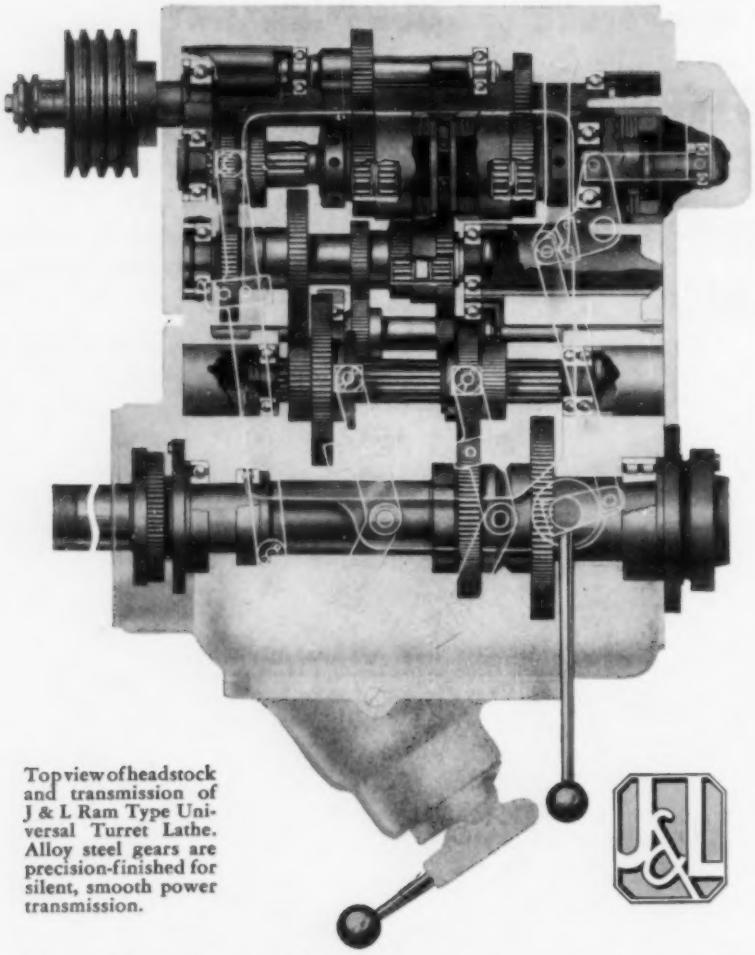
FAFNIR
BALL BEARINGS
MOST COMPLETE LINE IN AMERICA

A COMPLETE LINE OF HOUSED UNITS including:

CAST IRON PILLOW BLOCKS
LAK Illustrated

CAST IRON FLANGE CARTRIDGES
LCJ Illustrated

PRESSED STEEL "Economy" UNITS
Flangette Illustrated



Top view of headstock and transmission of J & L Ram Type Universal Turret Lathe. Alloy steel gears are precision-finished for silent, smooth power transmission.

Perkins Gears Used by Jones & Lamson

Jones & Lamson Machine Company, famous as manufacturers of the world's most accurate and powerful turret lathes, use Perkins precision gears for efficient, dependable performance. Perkins custom-cut gears are precision-made to exact specifications. They eliminate wear, noise and backlash. Our OEM customers know Perkins means dependable service and longer gear life. Perkins' long experience in producing precision gears could bring profitable benefits your way, too! Ask our engineers to work with you designing or estimating your next gear order.

WRITE TODAY for folder showing bevel, spiral, helical and spur gears; ratchets, sprockets and ground-thread worms; face gears, generated and curvic clutches; made by Perkins in many sizes from all materials.

Perkins Machine & Gear Co., West Springfield, Mass.

Name_____

Company_____

Address_____

PERKINS

MACHINE AND GEAR CO.

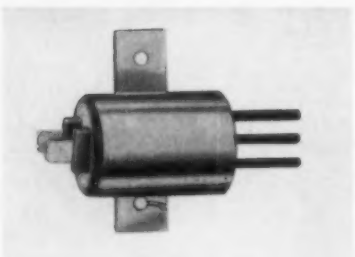
Dept. 42, West Springfield, Mass.

Telephone: REpublic 7-4751

contact arrangements. Rated at 250 mils, non-inductive load a-c, 30 w max. The button switch comes in red or black, non-locking.

Also available is a subminiature design with insulated springs that are interlocked by notched phenolic washers. A one-piece plastic shaft, red or black, eliminates removal of the button when inserting the switch through the mounting panel. Integral contacts are suitable for low-level circuits where low resistance is not a factor. Two contact arrangements are produced, with red or black plastic pushbutton, non-locking. Switchcraft, Inc., 1328 N. Halsted St., Chicago 22, Ill.

For more information—
Circle 36, inside back cover



Electromagnetic ¼ hp Motor Starter

An electromagnetic switch actuated by a plunger carries UL-approval as a ¼ hp industrial motor starter. This device is totally enclosed in a metal case. Three contract leads, plugged with molded bakelite, are equipped with AMP or Douglas type terminals. The coil has two AMP terminals. Available for any voltage from 6 to 230 v, 60 cps a-c, or from 6 to 110 v d-c. Contacts are rated up to 8 amp at 115 v, non-inductive. Standard contact combination is single-pole, normally open or closed, double-break-or-make. Unit is $2\frac{31}{32}$ x $1\frac{7}{32}$ x $1\frac{5}{32}$ in. Guardian Electric Mfg. Co., 1621 W. Walnut St., Chicago 12, Ill.

For more information—
Circle 37, inside back cover

Vernier Potentiometer

This vernier potentiometer, with three-terminal construction, is for use in circuits having a common ground.

(Continued on page 242)

cool metal for hot planes

For jet and rocket aircraft engines, wings and surfaces that are subject to extreme conditions of heat, friction and corrosion, where the metal *must stand up* . . . design it, improve it and protect it with McLOUTH STAINLESS STEEL.

specify

McLOUTH STAINLESS STEEL

HIGH QUALITY SHEET AND STRIP

for aircraft

McLOUTH STEEL CORPORATION DETROIT, MICHIGAN

MANUFACTURERS OF STAINLESS AND CARBON STEELS

NICE BEARINGS

Help Advance

X-RAY DESIGN

Modern techniques in radio-graphic practice have placed new demands on X-ray tube capacity. These demands have been answered by Machlett Laboratories, Inc., Springdale, Connecticut, by the introduction of their DYNAMAX design. The Machlett DYNAMAX design incorporates a rotating anode mounted on highly specialized ball bearings made by NICE BALL BEARING COMPANY.

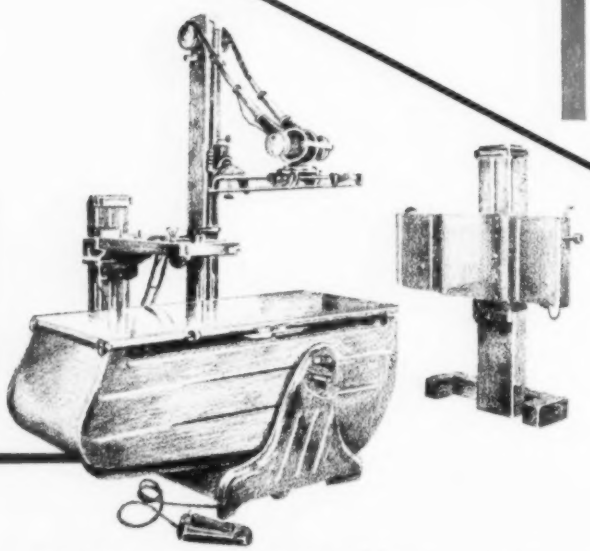
The commercial success of the rotating anode principle is largely due to the development of suitable bearings. The NICE bearings used by Machlett have proven to be the complete answer to all requirement problems. They are made to exacting tolerances from special heat resisting steel and are silver lubricated for use in high vacuum.*

Now Available! New NICE Cat. No. 190

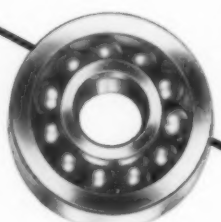
*Machlett U. S. Patent No. 2,315,280

Machlett DYNAMAX "25" Rotating Anode X-RAY Tube (with plastic display case)

Cutaway View of Ball Bearing Mounted Rotating Anode and Motor Armature Core



Picker X-Ray Corporation Table and Tube-stand incorporating Machlett DYNAMAX



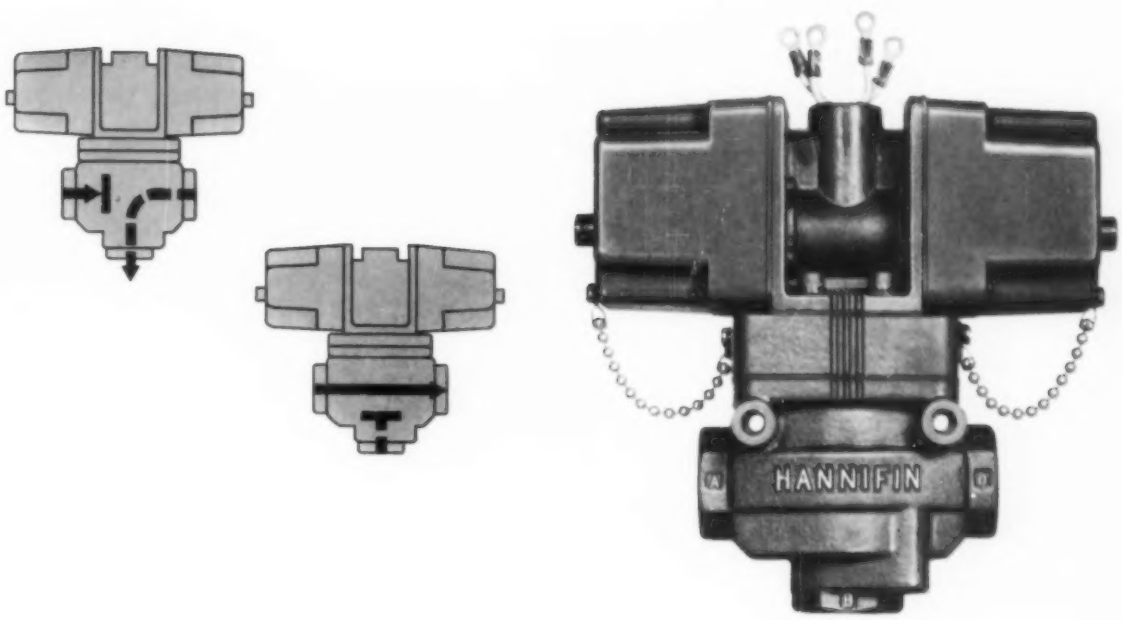
Special NICE Bearing used at bottom of Rotor. A similar Special Bearing is mounted at top of Rotor.

NICE is the word for **BEARINGS**

NICE BALL BEARING COMPANY
NICETOWN · PHILADELPHIA · PENNSYLVANIA

Setting the pace for automation

...Hannifin valves



Automatic processes call for speed, sensitivity and flexibility in directional air control. Above all, they demand dependability. That is why so many valve users find it pays to choose Hannifin.

Every feature that contributes to dependable performance has been incorporated in Hannifin air control valves. This dependability is the result of never-ending research and development.

In the broad Hannifin line, you will find valves with new exclusive features... valves for practically any kind of automatic sequential operation. All are simple in design, with few and easily replaceable parts.

AIR CONTROL

HANNIFIN

VALVES

For this complete catalog showing all the Hannifin directional air control valves, write to Hannifin Corporation, 525 South Wolf Road, Des Plaines, Illinois.

Felt has the Guts to "SNAP-BACK"!

No doubt about it — Felt by Felters is "teased" into just the right fiber arrangement for extra resiliency and long wear.

It does not crumble under pressure or deteriorate under continuous operation. Has predictable permanent set, is not adversely affected by age, water, oil, gasoline or acid in normal concentrations. It can be used with glass, wood, metal or plastics and treated chemically to meet technical and industrial requirements.

FELT IN USE . . . Felt is widely used as filtering medium, from the respirator use shown here to filtering out impurities in oil and similar fluids. Felters Felt comes in variety of densities, has high absorption and is an effective, low-cost seal against dust and dirt.

Free Design Book

Find out about *all* the ways felt can help you in product design. Complete data in handy form, even to selection and ordering of right grades. It's yours for the asking. Send for it today: The Felters Company, 228 South Street, Boston 11, Mass.

Get the Best, Specify

FELT by FELTERS

Manufacturers of Felt and Felt Products — *Represented in All Principal Cities*

FES-24

A single knob controls two resistance decades. Standard resistance ranges are 1,000, 10,000 and 100,000 ohm. Accuracy is ±5% of full-scale resistance. Linearity is ±0.5%. Resolution is 0.1%. Power rating is 4 w when used as a potentiometer and 20 milliamp when used as a rheostat. Elimination of helical elements allows accurate operation over a wide frequency range from d-c to 10 kc. The unit mounts, assembled like a panel meter. Research Instrument Co., P. O. Box 9168, Portland 16, Ore.

For more information—
Circle 38, inside back cover

Polyester Web Tapes For Electrical Insulation

Two electrical insulation tapes with higher tensile strength are commercially available in widths up to 44 in. and lengths up to 720 yd. The nonwoven tapes have conformability and elongation that permit snug fitting to irregular surfaces without pulling apart, strength retention up to 430 F, and moisture absorbency of 0.5%.

In conjunction with these polyester webs, a coated insulation has also been introduced. It is reported that this tape can be pulled tightly around irregular surfaces, eliminating air pockets. Minnesota Mining and Mfg. Co., 900 Fauquier Ave., St. Paul 6, Minn.

For more information—
Circle 39, inside back cover

Electric Brake for Standard NEMA C Motors

This disk brake has been re-designed to fit any standard NEMA C face motor. A taper lock bushing pro-

(Continued on page 244)

BIRDSBORO found

STEEL FDRY. AND MACHINE CO.

WICHITA

CLUTCHES and BRAKES

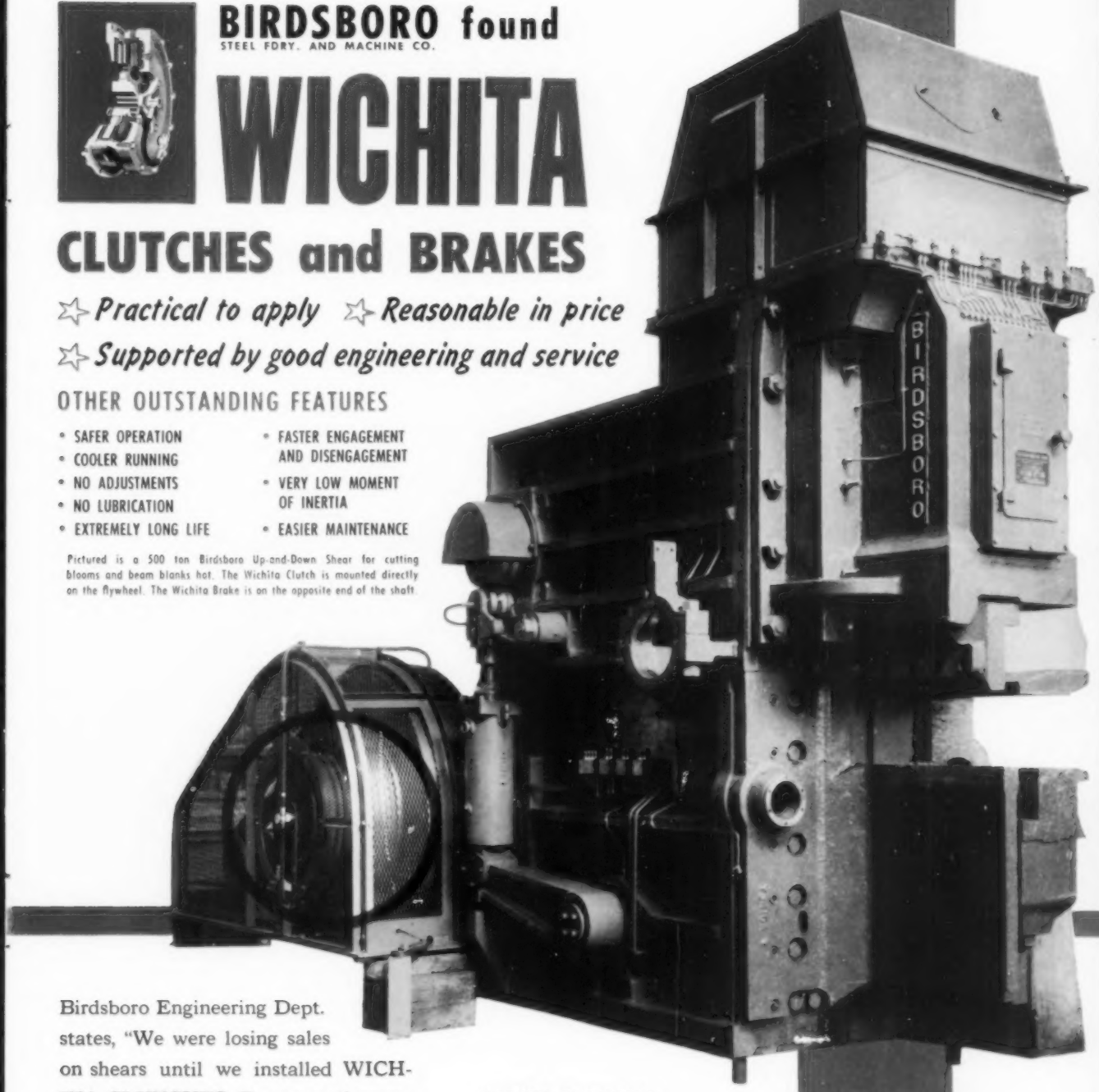
☆ *Practical to apply* ☆ *Reasonable in price*

☆ *Supported by good engineering and service*

OTHER OUTSTANDING FEATURES

- SAFER OPERATION
- COOLER RUNNING
- NO ADJUSTMENTS
- NO LUBRICATION
- EXTREMELY LONG LIFE
- FASTER ENGAGEMENT AND DISENGAGEMENT
- VERY LOW MOMENT OF INERTIA
- EASIER MAINTENANCE

Pictured is a 500 ton Birdsboro Up-and-Down Shear for cutting blooms and beam blanks hot. The Wichita Clutch is mounted directly on the flywheel. The Wichita Brake is on the opposite end of the shaft.



Birdsboro Engineering Dept. states, "We were losing sales on shears until we installed WICHITA CLUTCHES. For some time we had been trying to apply air-operated friction type clutches to our shears, but only WICHITA Clutch Engineers were able to give us a clutch that was satisfactory."

"Wichita Clutches have benefited our equipment most because they eliminate the need for either unsatisfactory mechanical jaw-type clutches or expensive direct drive start and stop."

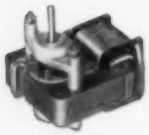
WICHITA ENGINEERS

Brehm-Lahner, Inc., Detroit, Mich.
L. H. Fremont, Cincinnati, Ohio
W. G. Kerr Company, Pittsburgh, Pa.
Smith-Keser & Co. (Main Office), Avon, Conn.
Smith-Keser & Co., Philadelphia 44, Pa.
Smith-Keser & Co. New York, New York
Frank W. Yarline Co., Chicago, Ill.
Larry W. McDowell, Long Beach, Calif.
Andrew T. Lobel, Denver, Colorado
Robert R. King Co., Cleveland, Ohio
Dominion Power Press Equipment Ltd., Burlington, Ontario, Canada
Allied Transmission Equipment Co., Kansas City 8, Missouri
R. E. Kunz, Seattle, Wash.
W. G. Ballantyne & Co., Portland, Ore.
Norman Williams, Houston, Texas

WICHITA Clutch COMPANY, INC.

WICHITA FALLS, TEXAS, U.S.A.

for RUGGEDNESS



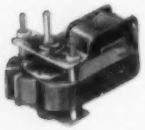
MODEL A
2-pole, shaded pole
AC Induction Type

MODEL B
4-pole, 4-coil shaded
pole AC Induction Type

RELY on GI

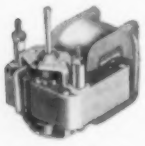
Fractional H. P. Motors

1/40 H. P. to 1/1100 H. P.



MODEL C
2-pole, shaded pole
AC Induction Type

The reputation of your product depends on the ruggedness of the motor that powers it. Specify G.I. for that important extra margin of dependability! Unexcelled performance records have made G.I. first choice of leading O.E.M.'s everywhere. We have the complete facilities, plus 50 years of know-how, to handle your job efficiently, economically — on time. Our design staff is at your disposal for special fractional hp. problems. RELY on G.I. !



MODEL F
2-pole, shaded pole
AC Induction Type

MODEL O
2-pole Capacitor Reversible
Type AC only (for 6, 12, or
24 volts)

MODEL E
4-pole, shaded pole
AC Induction Type

MODEL D
4-pole, 4-coil shaded pole
AC Induction Type

Write for complete specifications and quantity-price quotations today!

THE GENERAL INDUSTRIES CO.
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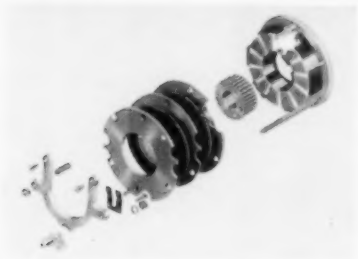


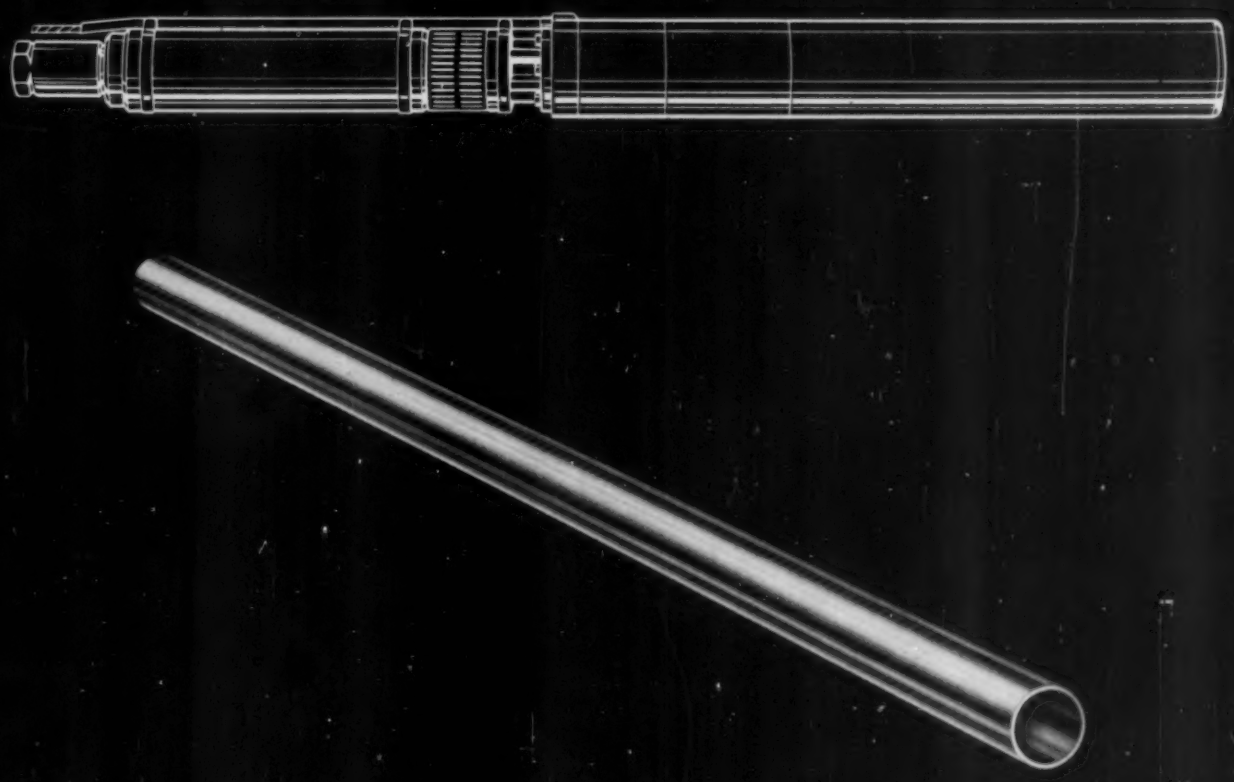
vides positive pinion retention and motor mounting without disassembly. Protection against coil burnout is provided with an air gap limiter. A magnet assembly pulls in from a large air gap and minimizes frequency of gap adjustment. Low rate springs maintain constant torque regardless of lining wear. An optional mechanical release has automatic or manual reset. Brackets are also available for foot mounting the brake as a separate unit. Brakes are rated 3 to 260 ft-lb. Star-Kimble Industrial Motor Div., Safety Ind., Inc., Hamden, Conn.

For more information—
Circle 40, inside back cover

Pushbutton Selector Switches

A line of pushbutton selector switches for temperature measuring circuits permit frequent checking of many remote thermocouples or resistance bulbs from one location. They also permit the averaging of temperatures from a number of sensing elements. Can be used with various types of pyrometers and resistance thermometers. Switches have crossbar palladium contacts with contact springs of tempered nickel-silver.

(Continued on page 247)



B&W ERW Mechanical Tubing Saves Time, Cuts Pump Production Costs 50%!

One manufacturer of submergible pumps had a bottleneck in its production line. The company had been using seamless tubing for their motor housings and pump housings—the design of the units called for precision tubing with close I.D. tolerances.

The company turned to B&W Electric-Resistance-Welded Mechanical Tubing.

After two years of using this close tolerance tubing, company engineers estimate they have been able to reduce their production costs on the components as much as 50%. What's more, the production of these parts has become the least troublesome in the manufacturing process!

Here's another example pointing out where B&W ERW Tubing is being used by industry to produce better products at lower cost. B&W Mechanical Tubing is available in a wide range of sizes, shapes, analyses, and finishes.

Get all the facts on savings from Mr. Tubes, your link to B&W. Call your local B&W tubing distributor. Write for Bulletin TB-419. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

TA-6088-M4

Seamless and welded tubular products, seamless welding fittings and forged steel flanges — in carbon, alloy and stainless steels

Let

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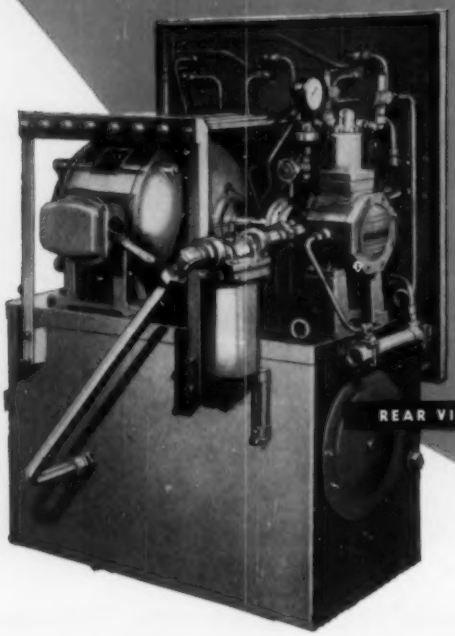
engineer your hydraulic needs

FRONT VIEW



REAR VIEW

A TYPICAL RACINE HYDRAULIC "POWER UNIT"

WHY RACINE FACTORY-ENGINEERED, FACTORY-ASSEMBLED *"HYDRAULIC POWER UNITS"* ARE BETTER FOR YOU!

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3. All components easily accessible for quick servicing
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Investigate RACINE'S *free* engineering service. Let Racine Hydraulic specialists relieve your engineering load. It will save you valuable time and money. Utilize this responsible single source of supply. Write us about your hydraulic projects. Your needs will receive prompt attention. No obligation.

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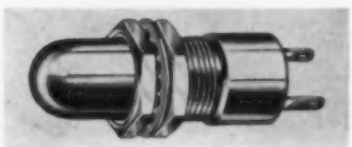
NFPA NATIONAL FLUID POWER ASSOCIATION

Member

RACINE HYDRAULICS & MACHINERY, INC.
2072 Albert Street
RACINE, WISCONSIN

Rectangular, welded-steel case is moistureproof and dusttight. Case capacities range from 12 to 72 points for thermocouples and resistance bulbs. Thermo Electric Co., Inc., Saddle Brook, N. J.

For more information—
Circle 41, inside back cover



Sub-miniature Pilot Light

This pilot light uses NE2D lamp, which draws 0.2 ma and consumes about 0.04 w of power. The lamp produces little heat and has an average life of about 25,000 hr. For 105 to 125 v or 210 to 250 v circuits, depending on the resistor used.

The pilot light which houses the lamp provides compact size and a stove-pipe-shaped cap of high-heat plastic for 180° visibility. Available in red, amber, yellow, and white. Metal parts are brass with black nickel finish, or white nickel, or chrome finished when so ordered. Terminals are perforated for wire and tinned for easy soldering. Dialight Corp., 60 Stewart Ave., Brooklyn 37, N. Y.

For more information—
Circle 42, inside back cover

FLUID POWER, CONTROL

Check Valve for Pumps

All-bronze check valve designed for submersible pumps in water systems has a flexible rubber poppet and is made of corrosion-resistant materials. It may be furnished drilled and tapped with one or two ⅛ or ¼-in. side outlet connections for attaching pressure switch, pressure gage, or snifter valve. Body is reinforced with heavy bosses which provide proper thread length for solid leak-proof connections on side outlets. It will work in any position.

Taper-type poppet is silicone treated

(Continued on page 250)

NO, NO... a thousand times "NO"

"NO loss of time," say the thousands of users of LAMINUM SHIMS...

NO machining!

NO grinding!

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LAMINATED SHIM COMPANY, INC.

Shim Headquarters since 1913

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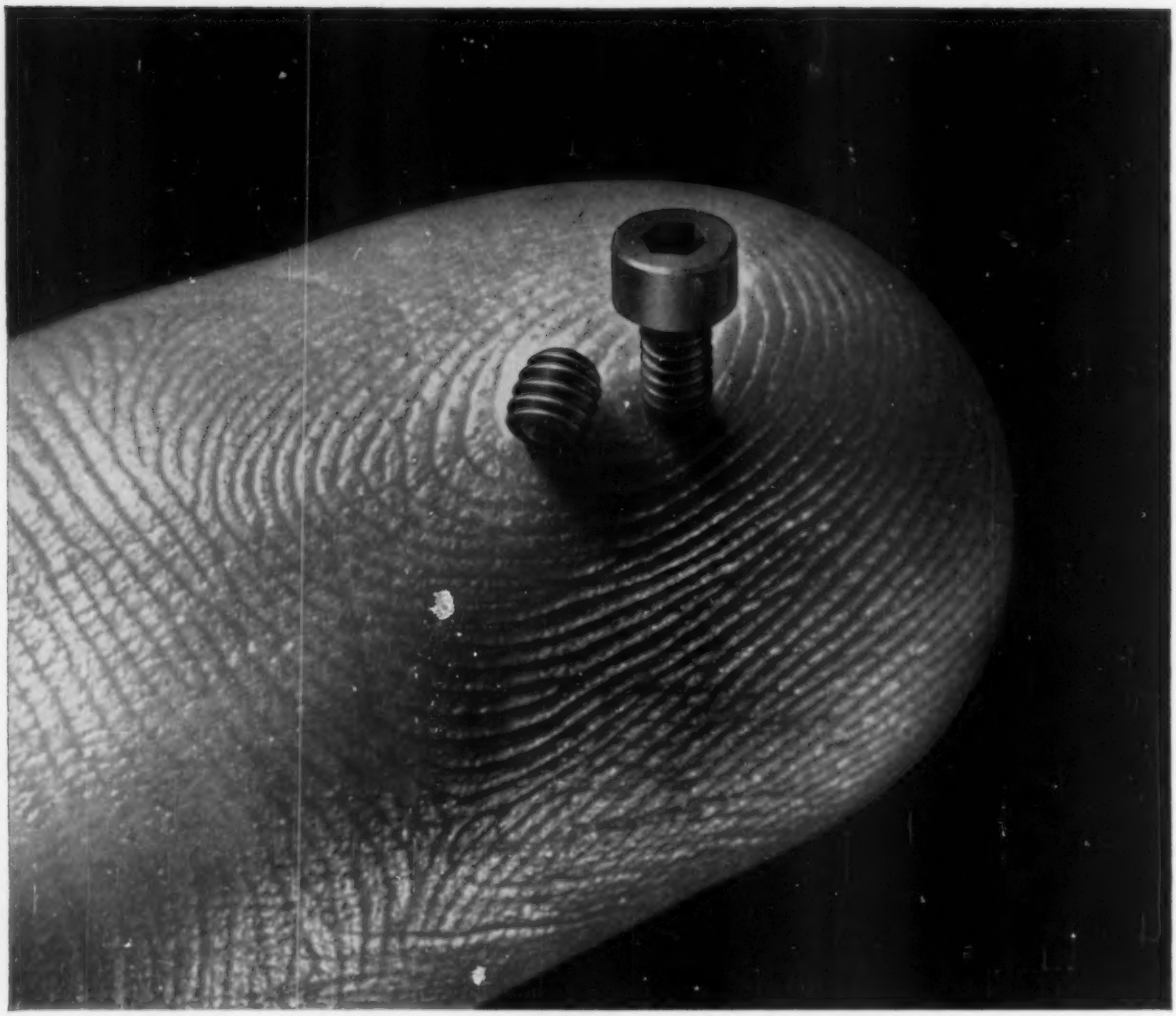

Cleveland miniature socket screws give extra strength in compact assemblies

Cleveland miniature cap and set screws eliminate the need for designing special screws to fasten parts in compact units. In countless intricate devices – servomechanisms, computers, typewriters, electronic and electrical equipment–they are used as functional parts permitting significant reduction in size, weight and cost without sacrificing strength.

Dimensions are held to very close tolerances. Accurately formed hexagon sockets insure high torque, nonslip wrenching, and maximum wrench holding power. Threads are rolled for accurate Class 3 fit and to gain extra fatigue and tensile strength. Alloy steel screws are carefully heat treated to obtain optimum of 180,000 psi minimum tensile strength.

Cleveland standard miniature screws are available from stock in both high quality heat treated alloy steel and nonmagnetic 18-8 stainless. Write today for prices and a copy of the Cleveland socket screw products folder.

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Socket head cap screws			Socket set screws, plain cup point		
Diameter	NC	NF	Diameter	NC	NF
#0	—	2.0	#0	0.5	0.5
#1	3.5	3.5	#1	1.5	1.5
#2	6.0	6.0	#2	1.5	1.5
#3	8.5	9.5	#3	5.0	5.0

THE CLEVELAND CAP SCREW COMPANY
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TO AUTOMATE YOUR MOTOR DRIVEN PRODUCTS...
GIVE THEM PRECISE, VARIABLE SPEED CONTROL...

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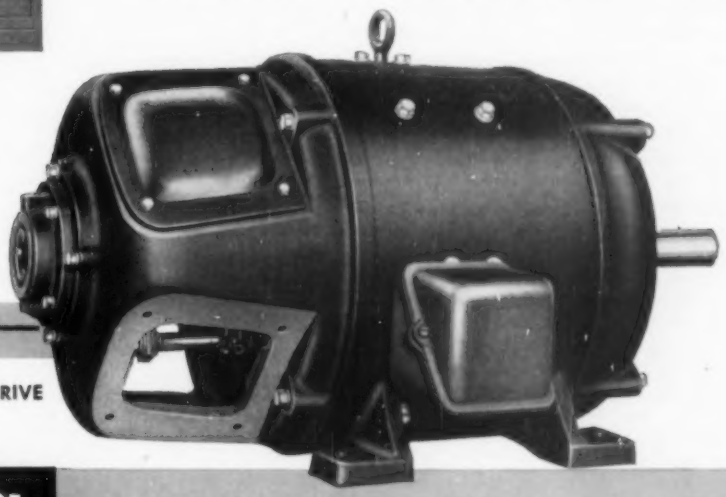
SELECTIVE SPEED DRIVE

How many of your customers could use the *full* potential of your product when given automatic operation by a Century Selective Speed Drive? Possibly more than you think.

Here's why. Predetermined, *automatic* manufacturing operations are faster, more accurate than manually controlled operations. A Century Selective Speed Drive on your product will respond to changes in operations—such as varying temperature, pressure, size, viscosity—and *automatically* adjust motor speed to fit the job.

Operating from AC, these drives offer a broad range of DC stepless speed control. They can regulate speed for individual drives or for precision interlocked multi-motor drives . . . can be used for jogging, normal or fast starts and stops, forward or reversing . . . and respond to a wide variety of remote control devices.

Century has more than 50 years' experience in engineering DC motors. For information on any motor application, call or write your nearby Century District Sales Office or Authorized Distributor.



76

Performance-Rated© MOTORS
1/20 to 400 H.P.

CENTURY ELECTRIC COMPANY

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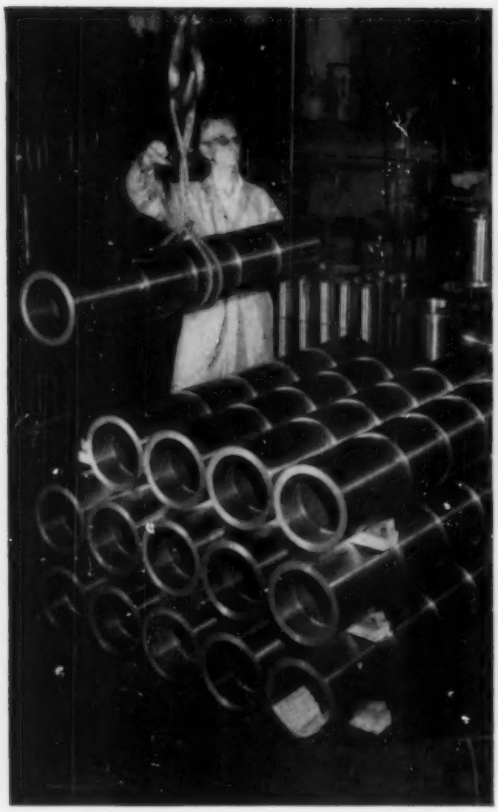

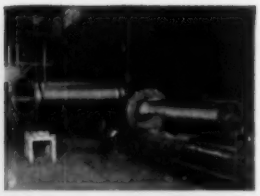

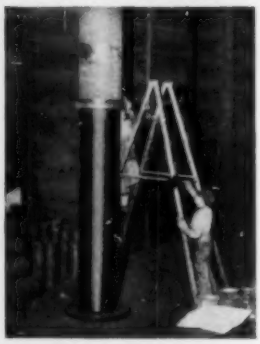

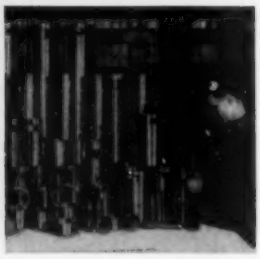

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SHENANGO CENTRIFUGAL CASTINGS

By using Shenango centrifugal castings for essentially symmetrical parts, you will gain considerable savings because:

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2. **No patterns required . . . an important saving, particularly on special or small quantity runs.**
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4. **With Shenango centrifugal method control, there's less excess metal to be machined away, less metal to buy and ship!**
5. **Because of their homogeneous, pressure-dense qualities, Shenango centrifugal castings are stronger, have better wear resistance and require less frequent replacement. Maintenance cost is cut!**

Check with Shenango on centrifugally cast parts for your needs —large or small castings . . . rough, semi-finished or precision-machined . . . ferrous or non-ferrous. They'll cost you less in the long run. For bulletins, write to: *Centrifugally Cast Products Division,* The Shenango Furnace Company, Dover, Ohio.

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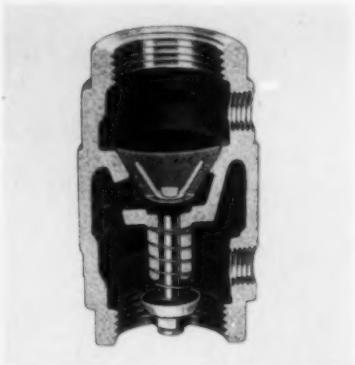
MONEL METAL • NI-RESIST • MEEHANITE* METAL • ALLOY IRONS



to open easily. Flexible lips seal tightly. Spring-loaded operation is sensitive and quiet. Made in four sizes from 1 to 2 in. Also available with stainless steel poppets for other types of service. Strataflo Products, Inc., Fort Wayne, Ind.

For more information—
Circle 43, inside back cover

Combination Gas Valve

This design incorporates a gas valve, pressure regulator, and safety pilot in a single, integrated unit. It features safe lighting, 100% safety pilot shut-off is available, and it may be used with all gases. The valve is a large-capacity unit capable of handling up to 300,000 Btu per hr. Detroit Controls Corp., 5900 Trumbull Ave., Detroit 8, Mich.

For more information—
Circle 44, inside back cover

PVC Lift Check Valve

An all-PVC lift check valve will operate in either a vertical or horizontal position and open and close

(Continued on page 252)

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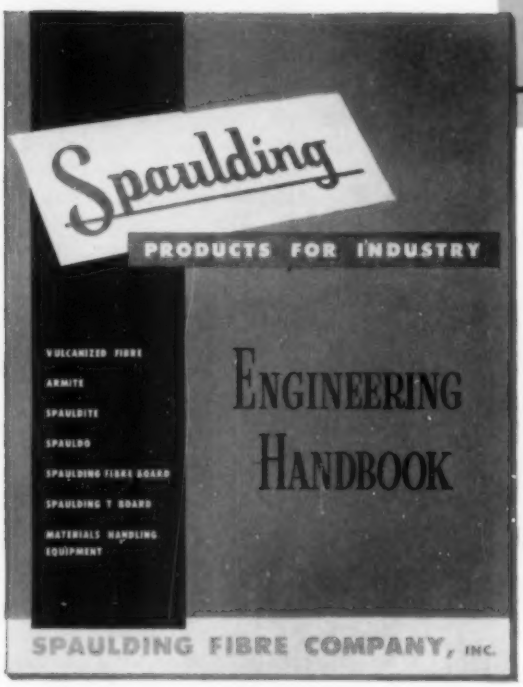

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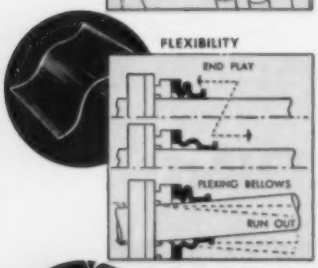
Shaft Seal Design With A Purpose!

POSITIVE DRIVE

This gives long seal life. Drive is transmitted through the driving band and washer driving notch which absorb all breakout and running torque. Damaging stresses on the bellows or flexible sealing member are eliminated. Slippage is also eliminated, thus protecting shaft or sleeve against galling.



FLEXIBILITY

Axial and radial misalignment problems are eliminated. Self-adjusting bellows or sealing head automatically compensates for shaft end play or run out. Minimum spring pressure is required for axial shaft movement and uniform spring pressure is maintained during radial shaft movement.

PRECISION MANUFACTURE

Leakproof performance is assured. Washer and seat surfaces are precision lapped to a perfect mate under a patented "John Crane" process.

A SEAL FOR EVERY SERVICE

All "John Crane" Seals are constructed to the particular service requirements . . . from hot or cold water to the most destructive acids, corrosives and gases . . . temperatures up to 1000°F. . . . pressures to 1200 psi. They can be furnished in types and sizes to meet practically any mechanical or dimensional condition.

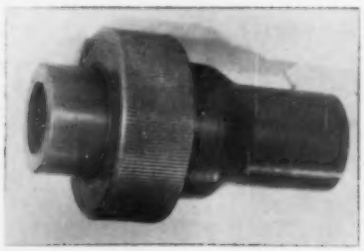
Request Bulletin S-204-2. Containing full information on "John Crane" engineered shaft seals.

GET COMPLETE DETAILS

Crane Packing Co., 6445 Oakton Street, Morton Grove, Ill. (Chicago Suburb)

In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

CRANE PACKING COMPANY



under less than 6 lb of pressure. A full 100% flow area is provided. The only moving part is a self-energizing disk. Available in ¼, ⅜, 1, 1¼, 1½, 2, and 3 in. sizes and in threaded or socket welding types. The material is normal impact PVC. Tube Turns Plastics, Inc., 2929 Magazine St., Louisville 11, Ky.

For more information— Circle 45, inside back cover

Automatic Air Filter For Pneumatic Equipment

An automatic ½-in. air filter for pneumatic equipment operates on intermittent air flow. It is designed to eliminate moisture, sludge, and other foreign substances heavier than air from air-operated devices.

The unit operates on a maximum of 90 cfm. Maximum working pressure is 300 lb. Internal parts have been irridited to pass a 100-hr salt spray test. Emco Pneumatic Corp., 1317 Locust St., Des Moines, Iowa.

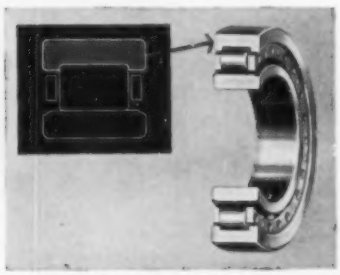
For more information— Circle 46, inside back cover

Motor-Operated Globe Valve

This valve has automatic disk compensation, tight shutoff, 150 lb pressure capacity on most sizes, no mounting restrictions, permanent lubrica-

(Continued on page 254)

Loggers' "weight-lifter" tests bearing stamina!



TWO-LIP RACE INCREASES RIGIDITY

Two parallel shoulders made integral with the outer race, as shown in gray above, increase rigidity and durability—keep rollers in proper alignment. Precision-ground rollers and races give quieter, smoother operation.

Tossing around logs 6 feet in diameter like toothpicks is no job for a softie! This machine has to be *built* for it right from the start—*right down to the bearings.* And that goes, too, for the trucks which haul these back-breaking giants over the most rugged terrain. Bower tapered and straight roller bearings have been *engineered* for just such work as this—to last longer, perform better under any road or load condition. Painstaking quality control plus basic bearing design refinements—like those shown at left—have reduced Bower Bearing failure to a practical minimum. *Whatever* your product, if it uses bearings, specify Bower! There's a complete line of tapered, straight and journal roller bearings for every field of transportation and industry.

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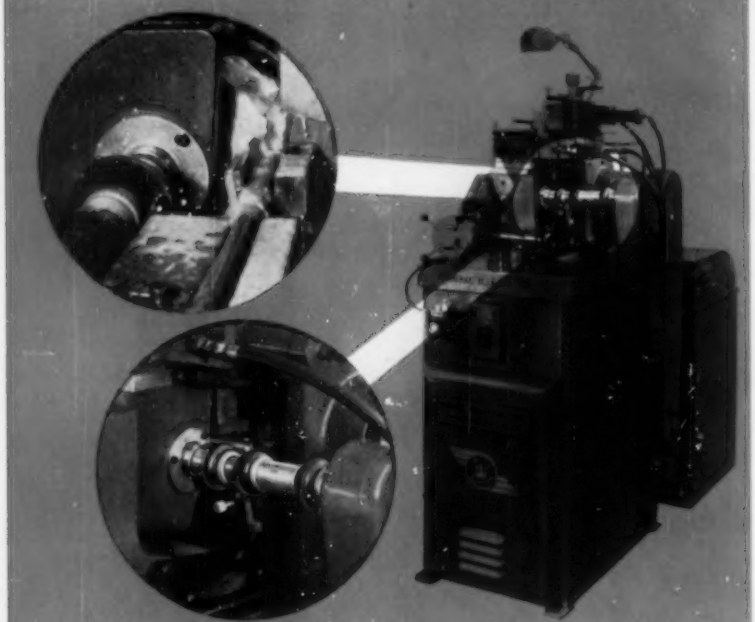
FEDERAL-MOGUL-BOWER BEARINGS, INC. • DETROIT 14, MICHIGAN

BOWER ROLLER BEARINGS

the APEX universal joint assembly on the Royal Master centerless grinder...



...insures minimum backlash, and operates efficiently in the midst of abrasives and coolant

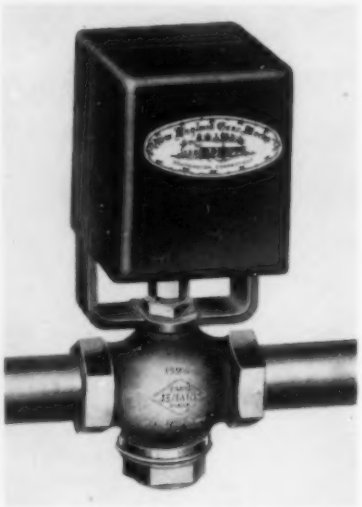
This Apex covered universal joint assembly transmits power from a variable speed drive to a regulating wheel on the Royal Master centerless grinder. The wheel must rotate smoothly, and with a bare minimum of backlash, so parts may be ground to extremely close tolerances. The location of the assembly is such that it is constantly subjected to a flow of coolant and to damaging abrasive particles.

Minimum backlash is achieved in Apex universal joints through a combination of sound design, selected quality materials and precision manufacture. Flexible covers, found only on Apex universal joints, provide clean, sustained lubrication, even in the midst of the stream of coolant; the covers also protect these precision-built joints from the damaging action of abrasive particles.

Apex industrial universal joints and assemblies, designed to help overcome your specific drive-line problems, can help make your product even better. Our new Catalog 28 is ready; write, on your company letterhead please, for your copy.

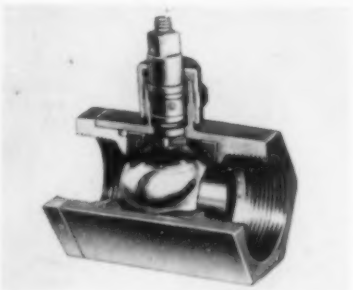
THE APEX MACHINE & TOOL CO.
1039 South Patterson Blvd.
DAYTON 2, OHIO

Phantom view of APEX covered universal joint which operates efficiently in wet or dry, corrosive or abrasive atmospheres, and in extremes of temperatures.



tion, positive operation without linkage, machine-cut hardened steel gears. The motorized valve is available in ten sizes, ¼ to 3 in. It has a Jenkins bronze globe body, three voltages, and three timing cycles, 8, 32 and 139 sec. It can be controlled by any positive action, single-pole, double-throw switch or pressure-actuated switches, on any of three voltages, 24, 115, 230 v. New England Gear Works, South End Rd., Southington, Conn.

For more information—
Circle 47, inside back cover



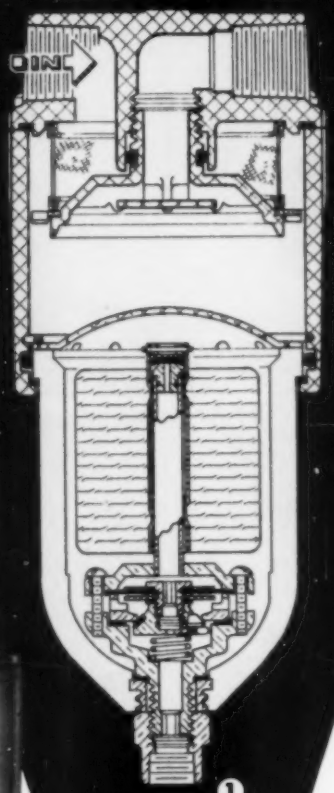
Vacuum Ball Valves

A line of ball valves is designed for high vacuum application in sizes from ¼-in. to 6 in. in either manually or air motor-operated models. They can be furnished in bronze, aluminum, mild steel, type 303 or 316 stainless steel, or PVC. All valves are tested for vacuum tightness on a helium-sensitive mass spectrometer leak detector.

The valves will hold vacuum in

(Continued on page 258)

NEW Advanced design Norgren AUTOMATIC-DRAIN AIR LINE FILTERS



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② WIDER OPERATING RANGE
5 psi to 250 psi, up to 200° F.

NOW—24 Models to choose from

- Transparent Bowls—¼", ⅜", ½", ¾", 1"
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BETTER... MORE EFFICIENT FILTRATION OF COMPRESSED AIR

You Get These Important Advantages:

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  Greatly increased water removal efficiency—even at air flows 143% higher than ever before.
- **Operates Over Wider Pressure Range**
  Top efficiency at as low as 5 psi for all models and as high as 250 psi for metal bowl type.
- **Operates Over Wider Temperature Range**
  New metal bowl models in ¼", ⅜" and ½" sizes extend temperature range to 200° F.
- **Withstand Rougher Usage**
  Metal bowl models are ideal for applications likely to get rough usage.
- **Simplified Drain Mechanism**
  More efficient operation. Fewer parts.
- **Eliminates Manual Draining**
  Collected liquid is drained automatically—cannot return to air line. Drain operates as long as pressure is on the system.
- **Choice of Three Filter Elements**
  74, 64 or 25 micron elements—interchangeable.

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For complete information, call your nearby Norgren representative listed in your telephone directory—

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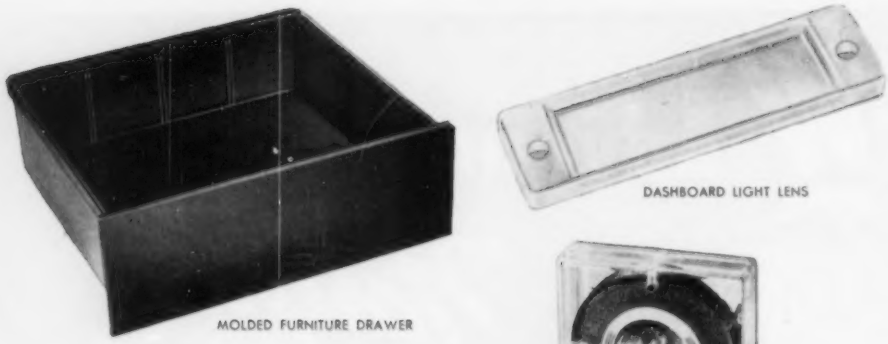

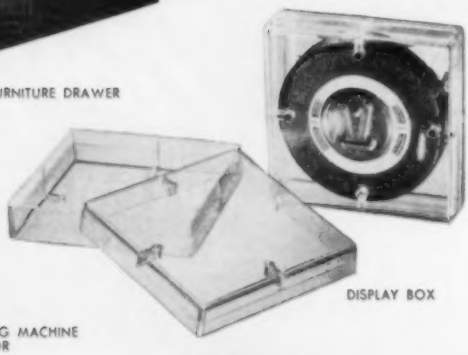

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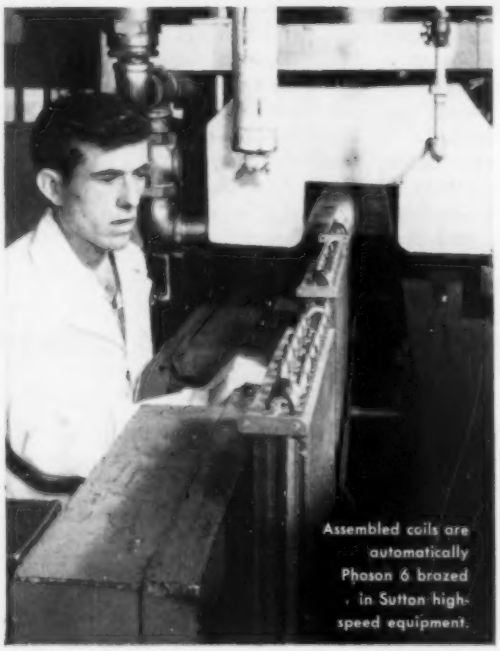
Phoson 6 rings automatically pre-loaded on copper return bends.

UNITED PHOSON 6 MAKES AUTOMATION IN BRAZING PRACTICAL... HIGHLY PROFITABLE

Brazing, too, can be fully automated. With the equipment shown, brilliantly engineered by The O. A. Sutton Corporation, up to 14,400 brazing rings are loaded every hour. Thanks to the high quality and precision tolerances of Phoson 6 rings, this company, one of the world's leading manufacturers of comfort cooling appliances, has increased assembly speed of copper return bends by 12 times!

From these hoppers 14,400 Phoson 6 rings are loaded every hour.

Phoson 6 rings provide the tight, slip-free fit automation demands.



Assembled coils are automatically Phoson 6 brazed in Sutton high-speed equipment.

To permit this amazing speed, brazing rings must fit tightly — perfectly — completely eliminating slippage prior to brazing. Here's how United Phoson 6 rings meet all the strict precision requirements of automation:

FIRST . . . Rings of Phoson 6 are preformed to exacting and uniform tolerance of +.000" to −.005" ID with a maximum helix of .015".

SECOND . . . at the lowest practical temperature, Phoson 6 brazes leakproof joints of highest strength, ductility, corrosion resistance and thermal conductivity.

These two points add up to one fact. You can profit now from automated brazing! Without delay, get the whole story. Write direct to United or see your nearby United Welding Supply Distributor.

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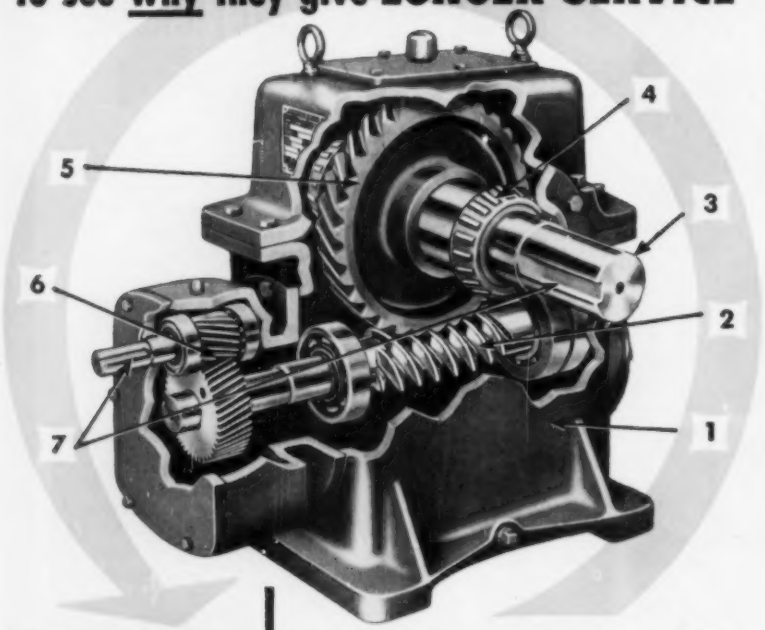
PROVIDENCE 7, RHODE ISLAND

COPPER, BRASS AND ALUMINUM WIRE AND TUBE . . . BRAZING ALLOYS, PHOSON, SIL-BOND

Look Inside a Foote Bros.

ENCLOSED WORM GEAR DRIVE

to see why they give LONGER SERVICE



1 EXTRA STRONG CAST HOUSING
Provides rigid mounting and alignment of caps and bearings. Made of high quality cast iron.

2 PRECISION ALLOY STEEL WORM
Integral with oversize shaft. Carefully matched to worm gear for quiet, trouble-free service.

3 OVERSIZE OUTPUT SHAFT

4 HEAVY DUTY, EXTRA LARGE BEARINGS
Oversize bearings used throughout unit. Worm bearings are combination single row radial and angular contact ball bearings. Input shaft bearings are single row radial type.

5 WORM GEAR
Precision generated from uniform density, high hardness virgin bronze alloy casting. High load carrying capacity.

6 HEAT TREATED HELICAL GEARS
Shaved for full tooth contact. Pinion integral with input shaft. Gear locked in position on worm shaft extension.

7 Just one of 10 different types, in a wide range of sizes, ratios and shaft arrangements.

One look at the oversize bearings, larger shafts, precision made gearing and the sturdy housing of a Foote Bros. Hygrade Worm Gear Drive tells you that *this* is a workhorse unit that will stand up and deliver under the toughest conditions.

Notice the carefully balanced design . . . greater mass where it's needed . . . the elimination of weight when it contributes nothing to efficiency . . . strength and toughness at the right places . . . the correct gear alloys . . . the compact design, and above all, the simplicity and ruggedness of this unit.

When you know the *inside* story of Foote Bros. Hygrade Worm Gear Drives, you can understand why they have built a reputation for quality, dependability, and performance that is unmatched by others.

Call in a Foote Bros. Field Engineer. Take advantage of our long experience in this business. Let us help you select or specify the most economical drive for your application.

Write for Engineering Manual HGB. It contains complete information on Hygrade Enclosed Worm Gear Drives.

this trademark stands for the finest industrial gearing made

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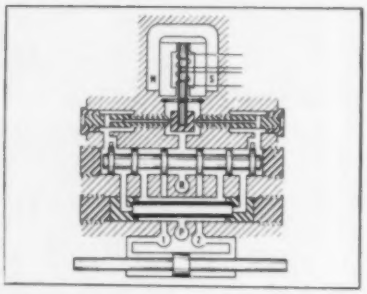
Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION
4575 South Western Boulevard Chicago 9, Illinois

either direction and are lightweight and compact, permitting mounting in any position. One-quarter turn of the stem provides opening and closing and precise throttling. In the full open position, the cross-section is circular and approximates the size of connecting pipes, making them suitable for vacuumtight locks where process material is introduced or removed. NRC Equipment Corp., 160 Charlemont St., Newton Highlands 61, Mass.

For more information--
Circle 48, inside back cover



Electro-Hydraulic Valves

The three models of this electro-hydraulic servo valves, designed for high-performance aircraft, are capable of functioning under rigorous operating and ambient conditions encountered. A closed loop hydraulic control circuit positions the output stage. The valves are of a balanced push-pull construction and have a minimum of moving parts. No springs are incorporated. As shown in the schematic drawing, the valves are two-stage electro-hydraulic flow control valves. Cadillac Gage Co., Detroit, Mich.

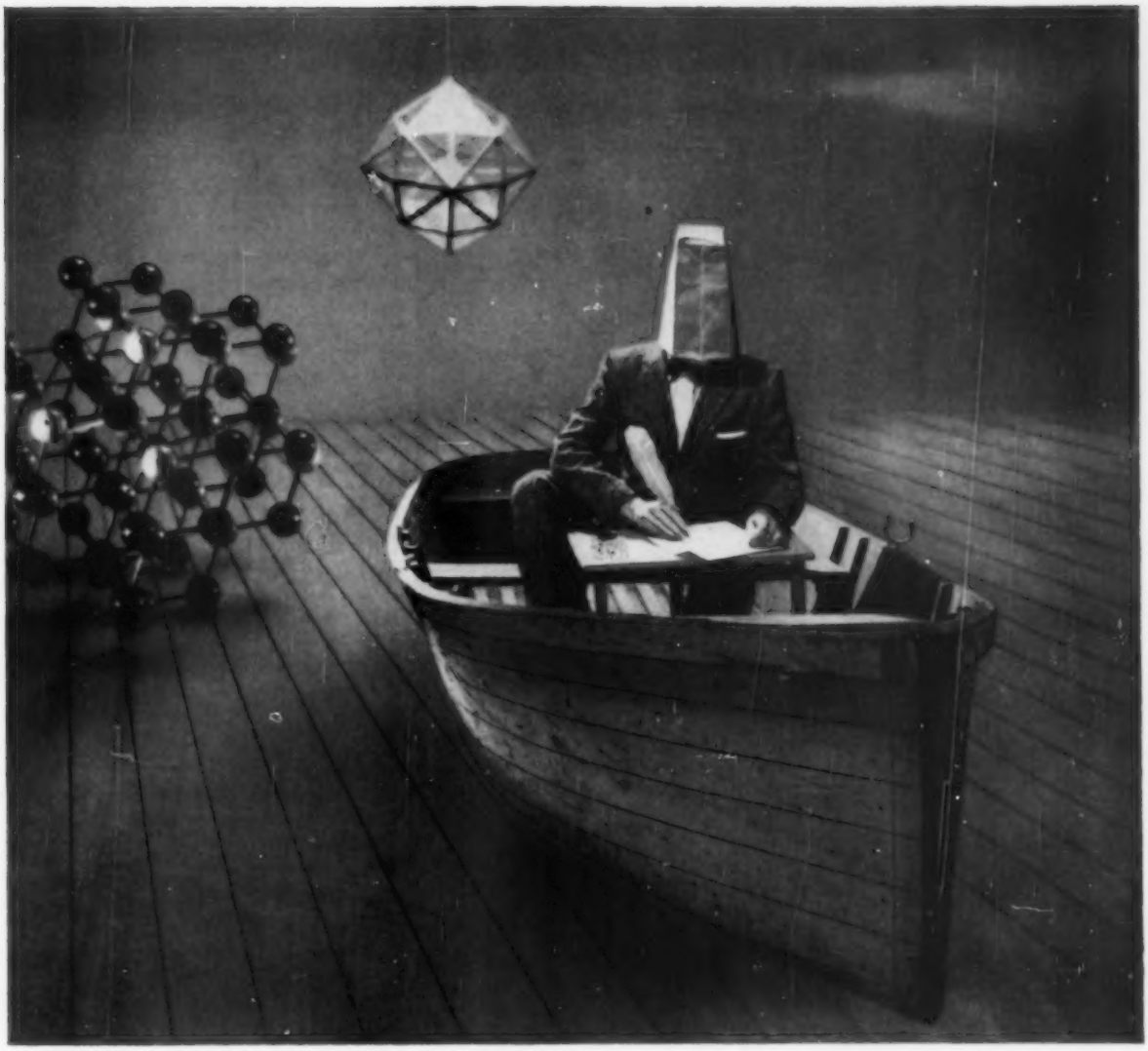
For more information—
Circle 49, inside back cover

ENGINEERING MATERIALS

Ceramic Bonds to Most Stainless Steels

A new ceramic material for hermetic seal applications with excellent electrical characteristics in continuous operation at temperatures up to 700 F bonds physically to most stainless

(Continued on page 260)



A Man Nobody Wants

This man's motto is "Don't rock the boat!" Now that he has reached his present high post in the Company, his life is dedicated to proving that once you get a good thing, you don't have to change. In fact, if things get too new, you can always search the past for something really safe to use.

He, naturally, has no interest in the new things coming out of Rogers.

Rogers is not looking for him, either. Rogers serves engineers – those men who sail the seven seas in search of an eighth. And they, in turn, find Rogers an interesting port of call – a cove of research and development brains eager to meet the challenge of their ideas with new materials.

Our business is to create – if we don't already have them – the materials that engineers are seeking to convert today's dreams into actual products. Please write for samples of recent developments.

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SHOE MATERIALS—for Counters, Midsoles, Liners, etc. PLASTICS—Special Purpose Molding Compounds and Laminates RUBBER—for Floats, Grommets, Gaskets, Bearing Seals, etc.
FABRICATING—Including Converting, Combining, Coating, Embossing, and Molding DEVELOPMENT—Research and Engineering of Unique Materials, Parts and Products

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ANY STROKE

AIR OR HYDRAULIC

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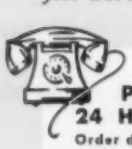
Get your cylinders *now*, when you need them. No need to lose production because of poor delivery! Carter will *ship your cylinder order in 24 hours or less*, to satisfy your needs. And when you buy Carter cylinders, you buy quality—rugged, dependable cylinders.

Leakproof construction... strong key-type locking of body between tubing and heads... compact, space-saving design. Everything you need in a cylinder... *plus special delivery to you.* Get in touch with us *today* for what you need *tomorrow!*



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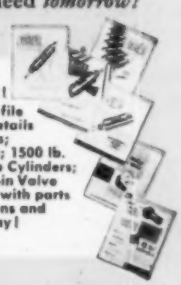

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AIR CYLINDERS • AIR VALVES • HYDRAULIC CYLINDERS
ROTARY ACTUATORS • SPECIAL CONTROLS

steels. The compound is available as pre-formed pieces, ready for firing by the user, or as completed seal components, such as single and multiple pin terminals and headers. Thermal expansion is said to be similar to the stainless alloys. Consolidated Electrodynamics Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.

For more information—
Circle 50, inside back cover

Heat-Resistant Phenolic Compounds

Two phenolic compounds can be molded into parts that withstand boiling water and oven-hot temperatures. Satin-finish withstands temperatures up to 500 F. Suitable for use in either cold-powder or pre-heated pill molding, the compound offers low shrinkage and minimum thermal expansion. The second molding powder is a medium heat-resistant material engineered to resist temperatures up to 400 F. Chemical Materials Dept., General Electric Co., 1 Plastics Ave., Pittsfield, Mass.

For more information—
Circle 51, inside back cover

Reinforced Plastic Withstands Temperatures to 258 F

A reinforced plastic that will withstand continuous sterilization temperatures of 258 F for a minimum of 24 hr without discoloration or shape distortion has been developed. It is produced by the matched-molding process. Structural Fibers, Inc., Fifth Ave., Chardon, Ohio.

For more information—
Circle 52, inside back cover

Teflon Tubing

Dimensionally accurate spaghetti tubing of virgin Teflon is offered in thin, standard and heavy wall construction in three grades and a range of sizes. Treated spaghetti tubing for potting operations has also been introduced to assure adherence of all potting compounds. Thin wall tubing is 30 to 0 gage with corresponding

(Continued on page 264)

New Design Trends for

Harvey Aluminum Extrusions

To any experienced engineer or designer, aluminum extrusions are a common commodity. You don't have to tell him that extrusions offer such advantages as ease of fabrication, design flexibility, etc. He knows that. What he wants to know now are the newest advances made possible by the extrusion process.

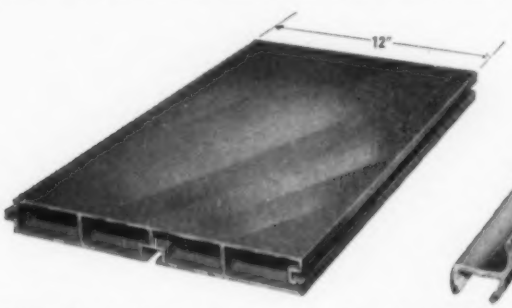
Potential for new configurations and applications

Typical new applications for Harvey Aluminum Extrusions are illustrated below. The design possibilities for aluminum extrusions are now practically limitless. Large heavy press sections; unusually complex shapes; wide, integrally stiffened skin panels; solid, hollow, and stepped extrusions; and extra long thin sections can be obtained from Harvey in all aluminum alloys. Heat-treated shapes can be produced in lengths up to 80 feet, weighing as much as 2,500 pounds. The maximum circumscribing circle diameter practical is 25½ inches. For functional, structural, or decorative applications demanding custom design plus light weight, corrosion resistance, high strength, and a naturally attractive finish, Harvey Aluminum Extrusions are first choice. And remember, Harvey is traditional for high quality and service.

Harvey Aluminum leads in extrusions

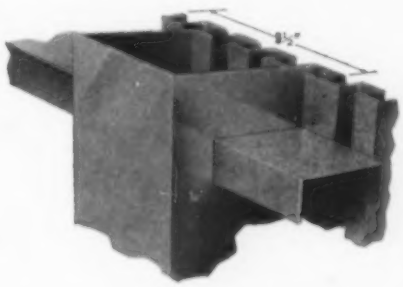
Harvey's completely integrated facilities include a large complement of extrusion presses ranging in size from 1400 tons to 12,000 tons, stretch-straighteners up to 3,000,000 pounds capacity for lengths up to 105 feet, and the newest supporting and finishing equipment.

If you have a problem with extrusions, thoroughly qualified Harvey specialists are always ready to help you improve your product. Write to Harvey Aluminum Sales, Inc., Torrance, California, or contact the nearest sales office listed under "Aluminum" in your classified telephone directory.



PANEL for highway signs. Extruded aluminum shape offers maximum strength and economy. Design combines several functions within a single shape. Light weight eases erection. Aluminum's natural, attractive finish and resistance to corrosion minimizes maintenance.

AUTOMOTIVE WINDOW FRAME combines utility with natural brilliance, eliminating costly plating operations. Rust is never a problem. This extruded shape typifies the trend in using aluminum for both decorative and functional applications in the automotive industry.



STRUCTURAL ASSEMBLY of extruded shapes is utilized for large span hangar and warehouse doors, building walls, and other components. Both structure and enclosure are formed by combining two aluminum extrusions. Interlocking design speeds and simplifies erection.

Making the most of aluminum . . . for everyone

HARVEY ALUMINUM SALES INC., TORRANCE, CALIFORNIA

HARVEY Aluminum

Harvey is a leading independent producer of quality aluminum products in all alloys and sizes: Rod and bar, pipe, tube, hollow sections, press forgings, forging stock, impact extrusions, structurals, special shapes, extrusions, screw machine products and other aluminum products. Harvey is also producing similar items in titanium and steel.

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INTO MANUFACTURING

Seam Welding—How to Use It To Improve Product Design and Quality

What is Seam Welding?

Seam welding is a method of fastening two metal piece parts with an uninterrupted joint, such as cylinder side seams, joining fuel tank halves, etc. It is a process that lends itself efficiently and economically to electric resistance welding techniques.

In practice, the two pieces of metal to be joined are overlapped and passed between a pair of rotating electrode wheels. Current is passed through in such a manner as to produce a line of overlapping spot welds. The resultant seam is pressure tight.

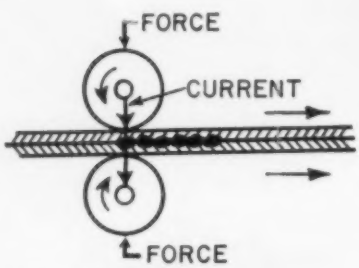


Fig. 1 Seam welding process.

Variations of the seam weld include *roll spot welding* in which the welds are made in the same manner but not overlapping. This method permits highly accurate spacing of spots.

Another form is the *mash seam weld* in which the materials to be welded are overlapped from one-half to twice the thickness of the sheet. The seam welder wheels actually mash or flatten the weld area to produce a seam only slightly thicker than one sheet of the welded material.

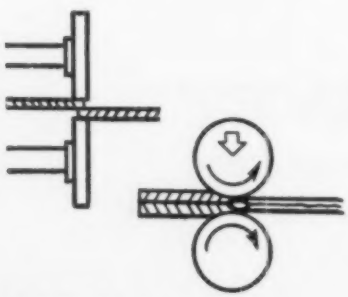


Fig. 2 Mash welding process.

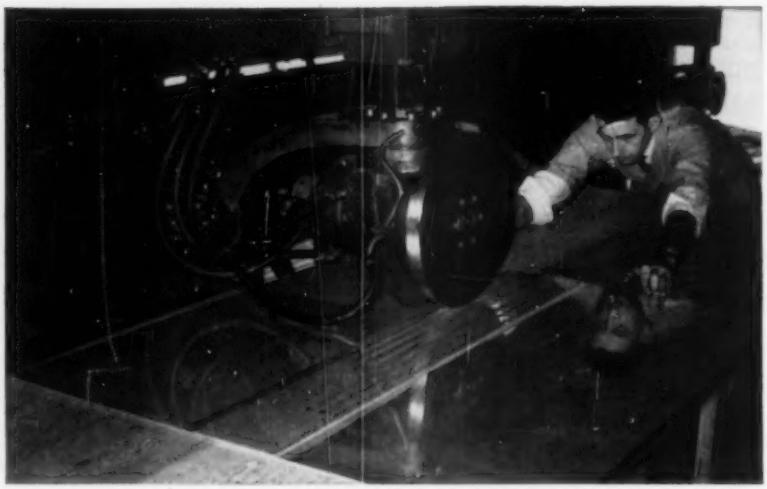


Fig. 3 Roll spot operation welding .125" to .125" of flat sheet aluminum alloy.

Advantages of Seam Welding

The seam welding process is readily adaptable to high production work which requires long linear welds. Pressure tightness is inherent.

Appearance of the weld is good. Minimum finishing is necessary only where surface appearance is critical. Distortion, so common in fusion welding, is negligible.

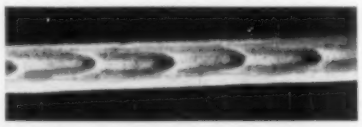


Fig. 4 Macrograph for continuous seam weld of .032" to .032" 24ST Alclad aluminum. Overlapping of the welds insures a water and fume tight seam.

Design Considerations for Seam Welding

As a guide to spacing which will produce an air or water-tight weld, there should be approximately 12 spots/in. in lighter gauges at a production rate of 12 feet/min. For heavier gauges figure about 8 spots/in. at a 2 feet/min. production rate.

Functional joint design will provide considerable savings if the piece part edge distance and work clearance can be accommodated by standard welder arms and electrode wheels.

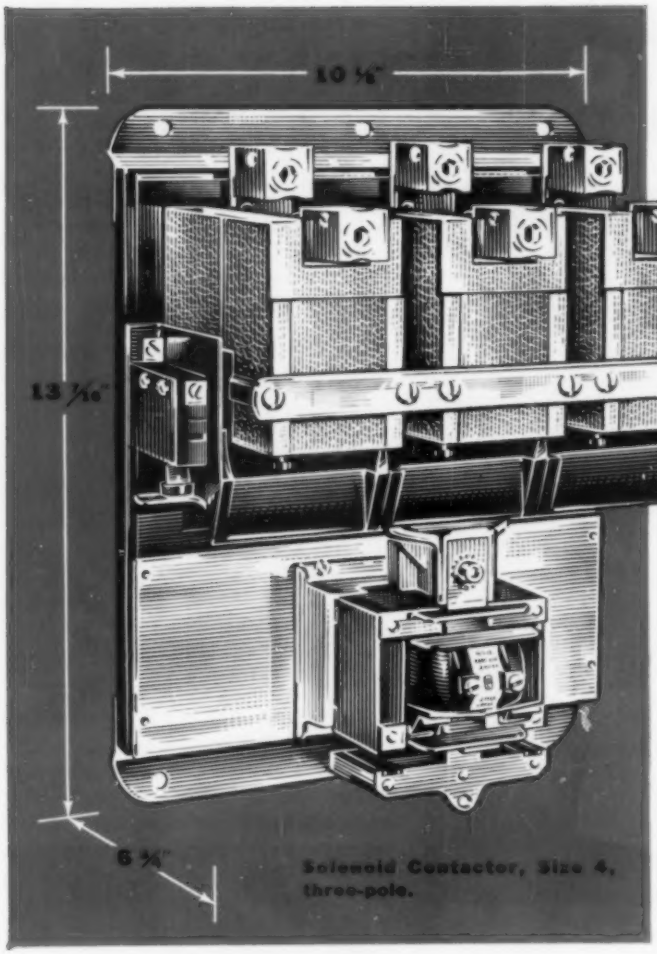
Sciaky Research Assistance

Facilities of the Sciaky Research Division at Los Angeles, California, are available for contract research to answer resistance welding problems. Housed in a 15,000 sq. ft. building, these facilities include an experienced engineering staff, a complete range of the most advanced resistance welding machines including the largest in the world and a laboratory equipped for metallography, chemistry, electronics, photography and testing as applied to resistance welding. Write for further information and ask for the 20-page Research Division brochure.

Write Today for Free Sciaky Literature

Start to build your data file on resistance welding today. Designers' Guide Bulletin 331 discusses seam welding and other forms of resistance welding.

Describe your particular fastening problem on company letterhead and we will send suitable back and future issues of our "Resistance Welding At Work" publication. All contain impressive examples of Sciaky's basic thinking—resistance welding techniques designed to do *more useful work at lower operating costs* with *maximum reliability*. **Sciaky Bros., Inc., 4913 West 67th Street, Chicago 38, Ill., POrtsmouth 7-5600.**



Solenoid Contactor, Size 4, three-pole.

NEW 150-amp solenoid contactor extends proven line

This new Size 4 A.C. solenoid contactor is ideal for use in motor starters and controllers for main line, accelerating and reversing purposes and for resistance heating and lamp loads as well.

It's the new Bulletin 4454—incorporating many advanced design features found on Ward Leonard's Sizes 0 to 3 contactors. Check these outstanding features:

New sintered-silver-cadmium-oxide contacts—can repeatedly handle high inrush currents without a sign of contact welding, excessive pitting or other damage.

Simple, compact solenoid design—excellent for modern metal control panels using accessible front-of-board wiring, particularly useful where panel space is limited.

Available with two or three main poles and up to 4 side-mounted auxiliaries. Also with provision for mechanical interlocking and addition of overload relays.

Completely described in Bulletin 4454. Write for your copy today. The Ward Leonard Electric Co., 63 South Street, Mount Vernon, New York. (In Canada: Ward Leonard of Canada Ltd., Toronto.) 7.6

ENGINEERING DATA

Size 4 A.C. Contactor Ratings*

Service	0-Hour Ampere Rating		Enclosed Power Rating	
	Open	Enclosed	Three Phase Volts	H.P.
Across-the-Line Starting	150	135	110 220 440-550	25 50 100
Across-the-Line Plug-Stop or Jogging	150	135	110 220 440-550	15 30 60

Service	0-Hour Ampere Rating	Single Phase Volts	Single Phase K.W.	Three Phase Volts	Three Phase K.W.
Resistive Heating Load**	150	110 220 440 550	15 30 60 75	110 220 440 550	26 52 105 130
Tungsten Lamp Lighting or Infrared Heating Load**	120 Amperes for 250 Volt Circuits or Less				

*The ratings listed are those recommended by the National Electrical Manufacturers Association.
**These ratings apply to open or enclosed contactors.

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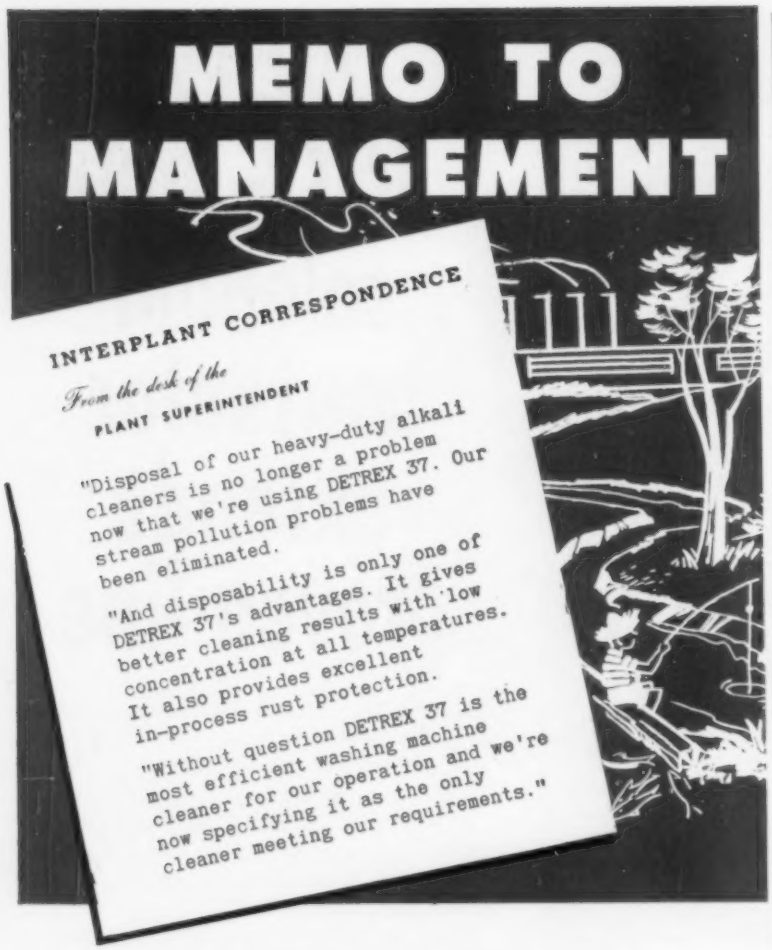

MEMO TO MANAGEMENT
INTERPLANT CORRESPONDENCE
From the desk of the
PLANT SUPERINTENDENT
"Disposal of our heavy-duty alkali cleaners is no longer a problem now that we're using DETREX 37. Our stream pollution problems have been eliminated.
"And disposability is only one of DETREX 37's advantages. It gives better cleaning results with low concentration at all temperatures. It also provides excellent in-process rust protection.
"Without question DETREX 37 is the most efficient washing machine cleaner for our operation and we're now specifying it as the only cleaner meeting our requirements."

ALL-PURPOSE DETREX ALKALI CLEANERS MAKE CLEANING OPERATIONS ECONOMICAL AND EFFICIENT

In addition to DETREX 37, DETREX manufactures a metal cleaning compound to meet every requirement in this field. Without obligation, a DETREX representative will analyze your specific cleaning application. Drawing from his experience and the wide range of DETREX water-soluble metal cleaning compounds, he can then recommend the one that will guarantee maximum efficiency in your metal cleaning operation.

DETREX service continues beyond the initial sale with regular checks on product performance and efficiency. Only DETREX provides such complete coverage—from recommendation of the proper method through installation to periodic counsel and service.

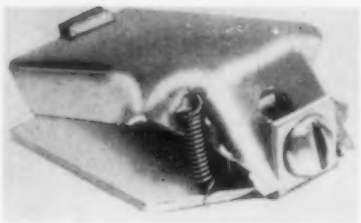
This "One-Source" efficiency has made DETREX, pioneer in the metal cleaning and processing field, the recognized leader. Let us show you how DETREX can recommend and service the most efficient methods, materials and machines to meet your requirements. Write today for information on increasing efficiency at lower cost.

DETREX CHEMICAL INDUSTRIES, INC.
BOX 501-A, DETROIT 32, MICHIGAN

nominal ID of 0.012 to 0.330 in. Standard wall tubing sizes range from 24 gage with a nominal ID of 0.022 in. to 30 gage with an ID of 0.330 in. Treated standard tubing sizes range from 0 through 24 gage. Heavy wall tubing is 24 through 5 gage with a nominal ID of 0.022 to 0.190 in. Fluorocarbon Products, Inc., div. U. S. Gasket Co., Camden 1, N. J.

For more information—
Circle 53, inside back cover

MECHANICAL COMPONENTS



Leveling Device

This device permits leveling of heavy appliances and equipment. Of heavy gage steel, the leveler provides four-point footing with up to ⅜ in. height adjustment. The adjustment is made through a small opening in the front of the cabinet or apparatus enclosure with a screwdriver or Allen wrench without tipping the unit. Normal installation consists of two levelers at the front and two standard glides at the rear. Chicago Sales Engineering, 1 E. Hillgrove Ave., La Grange, Ill.

For more information—
Circle 54, inside back cover

High-Strength Shoulder Screws

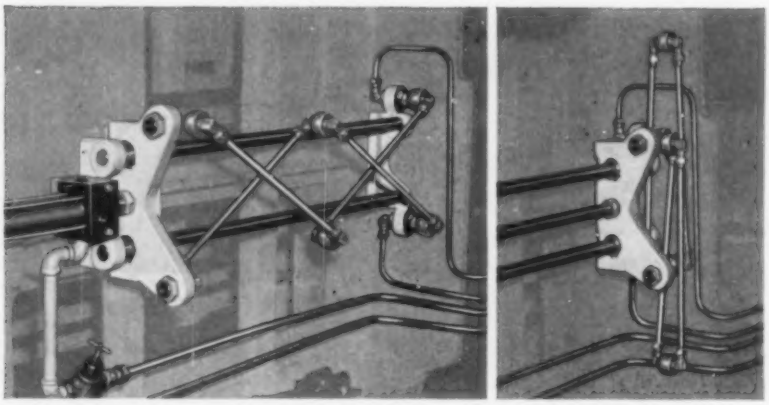
A line of upset-forged shoulder screws, in diameters up to 2½ in. and in any desired length, has been developed. The screws are said to have an unbroken and uniform grain flow, assuring high-strength characteristics. Made in hexagon head and a wide variety of intricate shoulder and other head shapes. The one-piece screw construction eliminates the need for inventories of bolts and bushings, and, as a further saving, cuts down as-

(Continued on page 268)

IN EQUIPMENT DESIGN ■

CHIKSAN SWIVEL JOINTS

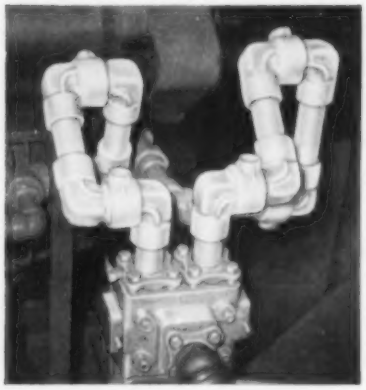
SMOOTH OUT KNOTTY LINE PROBLEMS



STEEL LINES FOLD LIKE AN ACCORDION

Connected to a moving head, these compact swivel jointed all-metal hydraulic lines flex and fold like an accordion on this automatic bottle unpacking machine.

When a machine's moving parts cause tight bend or twist on hose lines, Chiksan Swivel Joints provide a ready solution. When design dictates the use of metal lines, Chiksan Swivel Joints allow rubber-like flexibility. In fact, wherever line flexibility is required, designers and maintenance engineers know it's just good business to call on Chiksan. Precision made Chiksan Swivel Joints with their infinite service life, full 360° rotation and high safety factor, quickly pay for themselves by minimizing hose replacement and eliminating costly line failure, fluid loss and downtime. If your equipment hose lines require frequent replacement due to torsion or bend radii fatigue, or if flexible all metal lines are in order, contact Chiksan. A nearby representative will call, analyze your requirements, and make specific recommendations. Write today for his name.

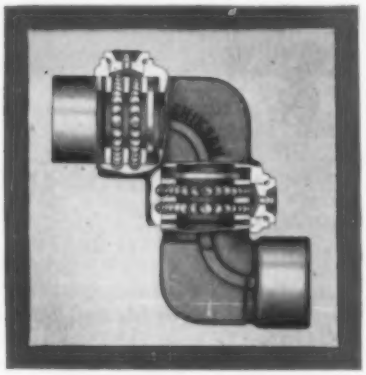


NO HOSE BURST HERE

These Chiksan swivel jointed steel lines on a die casting machine eliminate damaging hose ruptures, reduce fire hazard, fluid loss and setup time by 75%.

NO BEND FATIGUE HERE

This highly specialized lens grinder utilizes Chiksan Swivel Joints to eliminate tight hose bend as the multiposition head is shifted from one grinding position to another.



LOOK INSIDE A SWIVEL JOINT

Detailed attention to detail. Precision machining and specific packing seals for specific services. These are the quality-plus features built into every Chiksan Swivel Joint.

Please Address:
Dept. 207

CHIKSAN

fmc A SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION

CHIKSAN COMPANY—BREA, CALIFORNIA • CHICAGO 5, ILLINOIS • NEWARK 2, NEW JERSEY

Well Equipment Mfg. Corp. (Division), Houston 1, Texas • Subsidiaries: Chiksan Export Company • Chiksan of Canada Ltd.

MicroRold® 430
the general utility STAINLESS STEEL

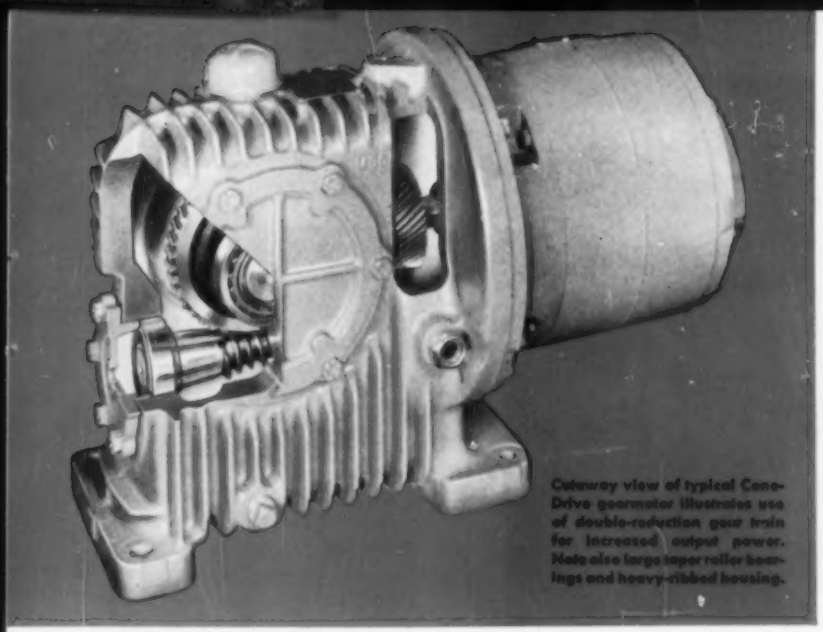
Since 430 meets military specifications, why not investigate this grade for your product

This straight chromium stainless grade possesses desirable qualities of beauty, corrosion resistance, strength, long life and low maintenance that are also of value in many civilian applications. More than 50% of all stainless applications could satisfactorily employ 430 stainless as an economical and practical material. Type 430 stainless costs 10¾ cents per pound less than the 18-8 grade. Some of our customers are already saving more than $215 per ton using our MicroRold 430 stainless sheet. Why not investigate the possibilities of this general utility 430 stainless.

Send today for your copy of our 24-page booklet, "MicroRold 430 Stainless Steel Handbook."

***MicroRold* 430 sheets** are available up to 48″ wide as thin as .010″, and up to 36″ wide as thin as .005″ in commercial finishes and tempers.

Washington Steel *Corporation*
8-G Woodland Avenue, Washington, Pa.



Cutaway view of typical Cone-Drive gearmotor illustrates use of double-reduction gear train for increased output power. Note also large taper roller bearings and heavy-ribbed housing.

Announcing a POWERFUL NEW DRIVE *by* CONE-DRIVE GEARS

Here are the "why's" for this new gearmotor

Why a right-angle gearmotor?
You save space! By tucking the entire unit in close to the driven shaft, there's nothing to stick out in crowded aisles. It's out of the way.

Why a double-reduction design?
More power! Combining a helical primary with a Cone-Drive double-enveloping worm gear secondary gives you an extremely high load-carrying capacity. Output torque ratings are much higher than those of single reduction gearmotors. Overall ratios are greater, too.

Why double-enveloping worm gears?
More power! Cone-Drive double-enveloping worm gears have proven that they provide maximum load carrying capacity on extremely small center distances. This means, in many cases, that they will handle two to four times the load of cylindrical worm gears of the same size. An added plus is high resistance to shock loads, long operating life and minimum maintenance requirements.

Why different types of mountings?
Flexibility! You can select Cone-Drive gearmotors with extended shaft or for shaft mounting. Both are standard. Shaft mounting often permits "hanging" the driven load on the gearmotor to eliminate pillow blocks, bearings, torque arms, shafts, pulleys, bed plates, etc. Both types may be floor, wall or ceiling mounted as desired.

Why 27 standard output speeds?
Standardization! Standard reductions range from 3.3:1 to 240:1. Speeds at 1750 rpm input range from 525 rpm to 7.3 rpm output speed. Any variation in input speed will naturally provide another complete set of 27 output speeds. Any standard type NEMA D-flange motor may be used. Other reductions may be obtained on special order at additional cost.

Why ratings to only 25 horsepower?
Demand! Extensive market research by Cone-Drive Gears reveals that this is the most popular power range in the application of gearmotors by industry. Currently we are building models in capacities from 1 to 25 horsepower. However the compact size and high capacity of the Cone-Drive gearmotor will extend this range in the future. Space requirements for higher capacities will be substantially reduced with our new design.

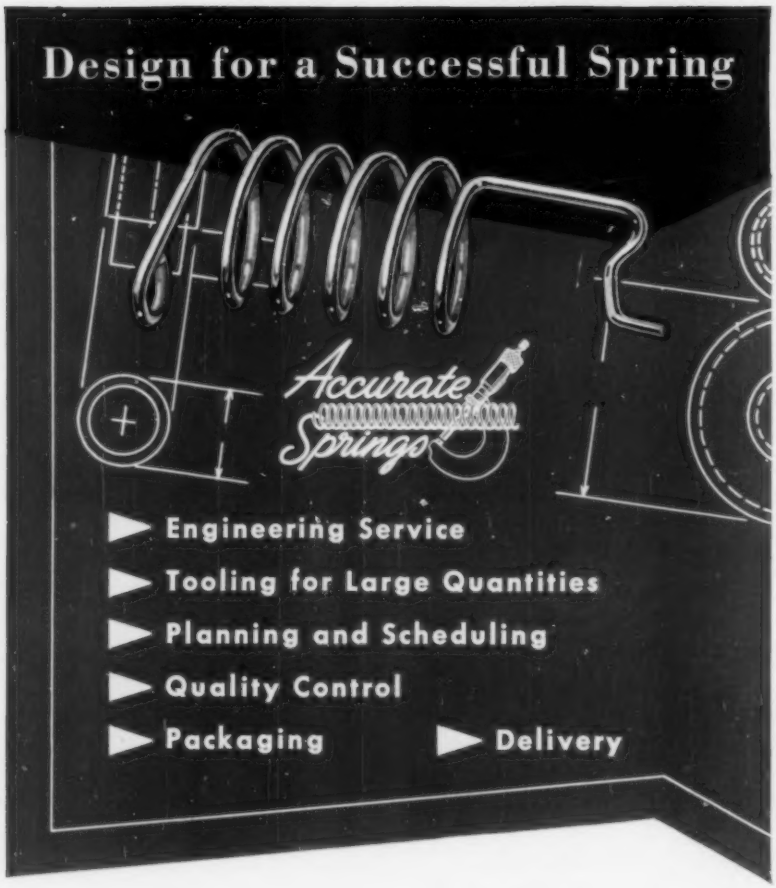
Why a Cone-Drive gearmotor?
Dependability! For over 20 years Cone-Drive Gears has been building double-enveloping worm gears and speed reducers. Design and manufacturing techniques have been constantly improved so that today these unique gears provide, size for size, the highest load-carrying capacity of any right angle worm gearing. Now, you can take advantage of this outstanding gearing combined into an integral package that eliminates pulleys, sheaves, belts, chain, bearings and all the trouble that goes with separate reducer and motor combinations. You'll get increased efficiency at lower cost by specifying standard Cone-Drive gearmotors.

Bulletin #57 contains complete details. Ask for it today.

◀ Here's the finest shaft mounted gearmotor on the market today. It is available in all sizes with ratings identical to other Cone-Drive gearmotors.

CONE-DRIVE GEARS
Division Michigan Tool Company
DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS
7171 E. McNICHOLS ROAD • DETROIT 12, MICHIGAN

Design for a Successful Spring



These are the basic elements necessary to design and produce a precision built spring. To supply the above elements takes skill, experience and imagination . . . ingredients that Accurate Spring provides every one of their customers every day.

Accurate makes millions of springs a month—precision springs held to close tolerances by rigid quality control and inspection. Production schedules for large quantities are planned well in advance. Customers are assured of deliveries scheduled to their needs.

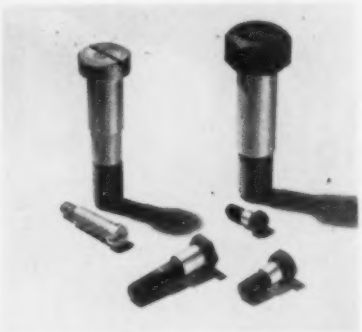
Proper packaging is necessary too, for ease of handling and speeded production. Untangling springs can be irksome and expensive.

These facilities are here to serve you. Just write, outlining your requirements and specifications.

Accurate Springs

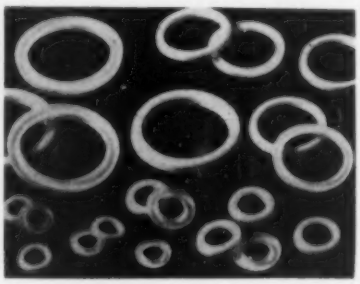
SPRINGS
WIRE FORMS
STAMPINGS

ACCURATE SPRING MFG. CO., 3815 W. Lake St., Chicago 24, Ill.



sembly time. The screws have important uses in manufacturing of a wide variety of assemblies where a close-tolerance bearing surface and high shear strength are essential. Cleveland Cap Screw Co., Cleveland, Ohio.

For more information—
Circle 55, inside back cover



Chevron Seals for —350 F to 500 F

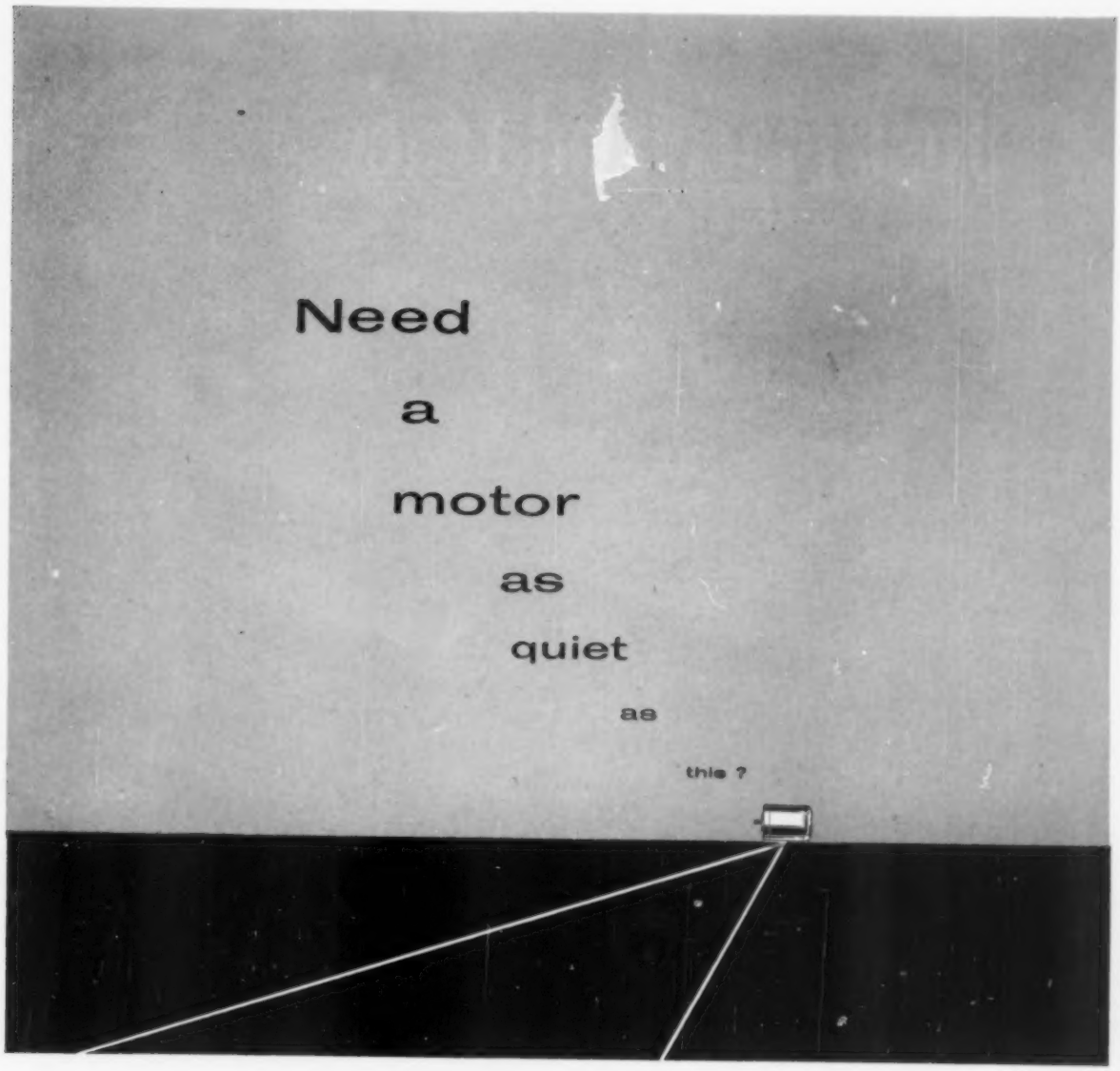
A molded dynamic and static chevron seal of Teflon is said to maintain size and leakproof characteristics at temperatures ranging from —350 F to 500 F and pressures from 0 to 1000 psig. They can be installed in both rotational and longitudinal movements in component metal parts as well as static positions. Joclin Mfg. Co., Wallingford, Conn.

For more information—
Circle 56, inside back cover

Clutches for Heavy Duty Equipment

A clutch arrangement uses friction material with a ceramic base for heavy-duty and off-highway type machines. Increased capacity, better heat disposal, better ventilation, cooler running, no fading, longer wear, fewer

(Continued on page 272)



FREE! This 24-page booklet explains when to specify *Customized* motors, shows design variations, illustrates case histories. Write Jack & Heintz, Inc., 17627 Broadway, Cleveland 1, Ohio.

Call Jack & Heintz—America's leading specialist in *Customized* motors, 1/8 to 5 hp (1/3 to 15 hp in submersible motors). We'll gladly devote as much time as it takes to design the motor that hushes operation of your product . . . a motor that *electrically*, *mechanically* and *physically* fits your product perfectly.

Customizing electric motors to meet the specific requirements of original equipment manufacturers *is our business*. Because we're organized that way, costs are reasonable to get the quiet, or torque or envelope you need. We can stretch a motor tall, squat it flat, customize it for ambient temperature rating. Make it submersible in a wide range of fluids. Give it flushness or a special finish. You name it!

So go ahead freely! Design your product to do its job. We'll fit a motor to it that will make your product perform the way you want it to . . . look as good as it should . . . last as long as you say it will . . . and sell faster because of it.

JACK & HEINTZ *CUSTOMIZED* ELECTRIC MOTORS

Lightweight, portable tracing unit is only 1 7/16 inches *thin*

Now you can trace *right at the drawing board*, and save precious minutes with PORTA-TRACE®—the thin, lightweight tracing box that *comes to you*.

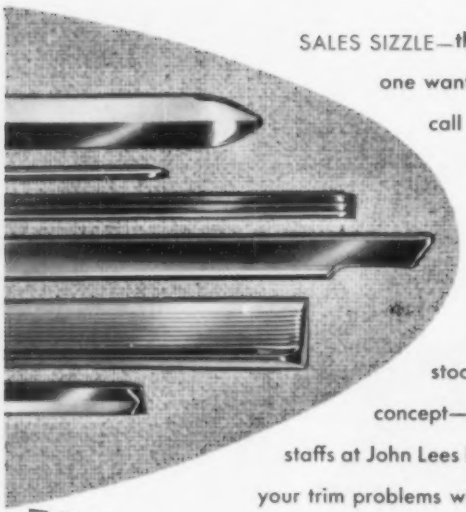
Simply pick it up . . . place it on your board . . . flick a switch and you're ready —in seconds!

Only 1 7/16 inches deep, PORTA-TRACE can actually be used under the straight edge of your drafting table! Its flush top permits use with drawings larger than unit itself. Strong Plexiglas top is enclosed by rugged, long-life stainless steel frame. Available in four sizes up to 24″ x 36″.

Save drafting time and precious space with PORTA-TRACE. Call your local Ozalid representative or write Ozalid, Dept. O-8, Johnson City, N. Y.

A Division of General Aniline & Film Corporation
In Canada: Hughes Owens Company, Ltd., Montreal

IN KITCHEN ACCESSORIES, TOO
Sharonsteel Quality STANDS OUT
• Many different types of steel are required in the manufacture of kitchen accessories. — Stainless Steels for trim and assemblies that come in contact with foods — Alloy Steels for parts that must absorb punishment — Carbon Steels for cutting blades, frames and cases. The ability to constantly produce a wide variety of quality steels is another reason why Sharon has always been a leading supplier to this ever expanding industry.
SOMOGOFF N.Y.
SHARONSTEEL
For 56 Years a Quality Name in Steel
SHARON STEEL CORPORATION, SHARON, PENNA.
CHICAGO, CINCINNATI, CLEVELAND, DAYTON, DETROIT, GRAND RAPIDS, INDIANAPOLIS, LOS ANGELES, MILWAUKEE, NEW YORK, PHILADELPHIA, ROCHESTER, SAN FRANCISCO, SHARON, SEATTLE, MONTREAL, TORONTO



SALES SIZZLE—that elusive phantom everyone wants to catch. Stop chasing—call John Lees and "genie-like" they will come with eye appealing rolled moulding for your product. Whatever your requirements may be — perhaps stock items or an entirely new concept—the design and engineering staffs at John Lees have one purpose—solving your trim problems with simplicity and dispatch.

Please send a copy of the new catalog.

NAME_____

POSITION_____

FIRM_____

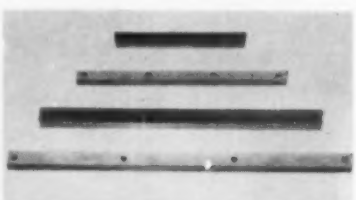
ADDRESS_____

Keeps You in "Trim"

division of THE SERRICK CORPORATION
Batavia at Kilgore, Muncie, Indiana

adjustments, and more usable lining material are some of the improvements claimed for the clutch. Available in over-center and spring-loaded models in a wide range of sizes up to 18 in., single and double plate. Rockford Clutch Div., Borg-Warner Corp., Rockford, Ill.

For more information—
Circle 57, inside back cover



Fine Pitch Gear Racks

A range of fine pitch racks is now available from stock in the following AGMA precision I pitches: 48, 64, 72, 96, and 120. Made in No. 303 stainless steel and aluminum. Pic Design Corp., div. Benrus Watch Co., Inc., 477 Atlantic Ave., E. Rockaway, N. Y.

For more information—
Circle 58, inside back cover

Hex-Head Self-Locking Screws

Standard hex-head cap screws have been made self-locking and self-sealing by means of a nylon pellet inserted in the threaded section of the screws. It eliminates the need for auxiliary locking devices. The screws retain their locking action from −70 F to 250 F, even after repeated heating and cooling cycles. They are said to

(Continued on page 276)

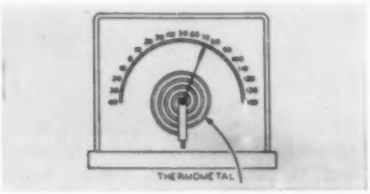
No. 1
of a series of ads dealing with basic facts about thermostatic metals.

Designing for Product Improvement With WILCO THERMOMETAL®

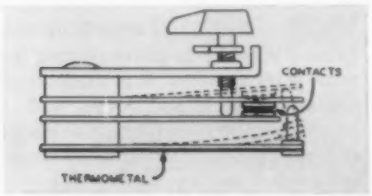
Thermometal (thermostatic metals) are laminations of two or more different metals with unequal coefficients of expansion. The difference in rate of expansion causes them to change shape with changes in temperature and, if restrained, to build up force.

This basic fact is of great industrial importance, for it makes possible the application of Thermometal in indicating and controls devices in 4 broad categories.

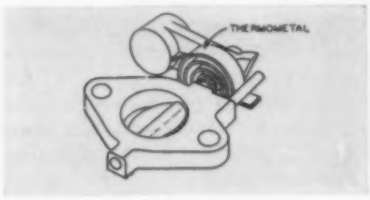
1. Temperature Indication, as in Thermometal thermometers.



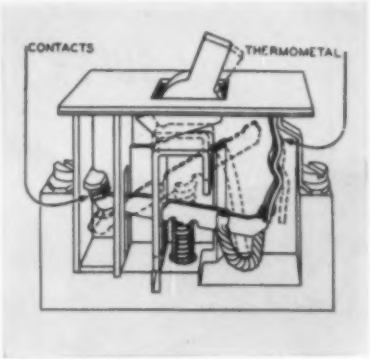
2. Temperature Control, as in electric Irons, toasters, or room thermostats.



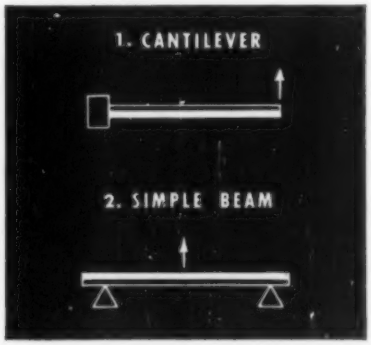
3. Temperature Compensation, as in automotive heat manifold control.

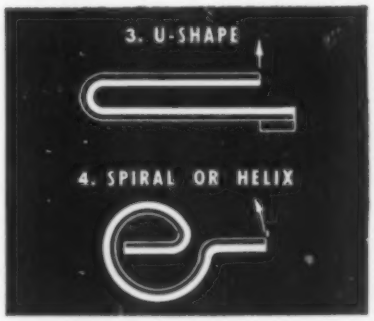


4. Sequence Control by Functional Heating, as in electric circuit breakers for overload protection.



Thermometal can be rolled to any desired thickness and formed into almost any shape, and still respond to temperature changes. For this reason it is a unique thermal element, which functions without linkages, seals, special mountings, and in most applications without electrical energy. Thermometal can be made to perform simple flexing motion, rapid snap action, and rotary or twisting motions. Four basic shapes are used alone or in combinations to obtain these motions:





According to the application, the selection of Thermometal is generally governed by four performance factors:

1. Maximum temperature encountered in service: (300°F, 500°F, 800°F, or 1000°F)
2. Temperature range over which maximum sensitivity is required: 50°–300°F (low); 150°–450°F (medium); 300°–600°F (high); 500°–800°F (extra high)
3. Deflection and force required
4. Electrical conductivity

The H. A. Wilson Company is the American pioneer in the development and manufacture of thermostatic metals. We produce over 40 metals for this use. Also we make a complete line of electrical contacts for use with Thermometal.

Reprints of this series are available on request. For further information about our products, ask for the Wilco Blue Book, the most complete reference manual ever written on Thermometal. And if you have an immediate application problem for Thermometal or other Wilco products, please tell us. Our engineering service is at your disposal.

WILCO®

THERMOMETAL
ELECTRICAL CONTACTS
COMPOSITE METALS
SPECIAL PURPOSE ALLOYS

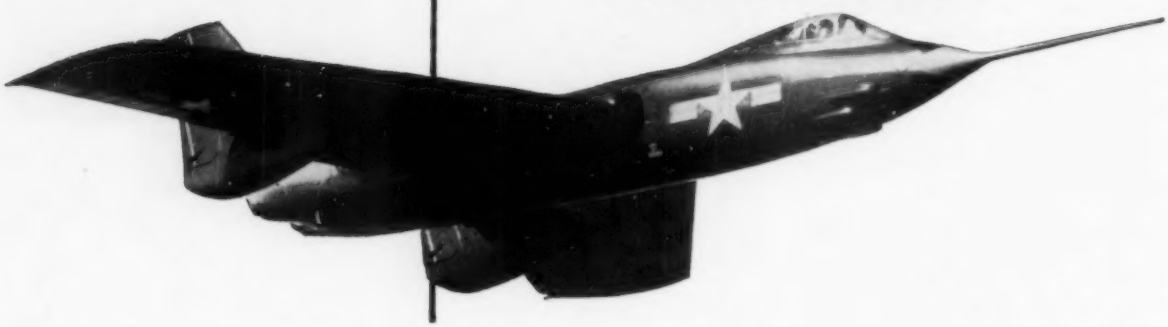
THE H. A. WILSON COMPANY
2655 U. S. Route 22, Union, New Jersey
Branch Offices: Chicago • Detroit • Los Angeles • Providence

ENGELHARD INDUSTRIES

For your selection

ALTEMP

HIGH TEMPERATURE SUPER ALLOY STEELS



ALTEMP A-286 . . . an austenitic iron-nickel-chromium alloy made heat-treatable by the addition of titanium. Designed to maintain high strength and corrosion-resistance up to the 1350 F range, and to afford satisfactory scale resistance up to 1800 F.

A-286 was developed in the A-L Research Laboratory in Watervliet, N.Y., in the 1949-51 period. Among the high-strength, heat-resisting alloys, it has exceptionally low strategic alloy content, improved hot-working and machining qualities, and good center ductility in large sections. Currently used in jet engines and superchargers for such applications as turbine wheels and blades, frames, casings, afterburner parts, bolting, etc.

This alloy is readily produced in large quantities without the need of special steel-making equipment. It is available in the form of billets, bars, forgings, sheet, strip, tubing and hot-extruded shapes.

ALTEMP S-816 . . . a chromium-nickel-cobalt base alloy, strengthened by additions of molybdenum and tungsten, and with a columbium-carbon ratio of ten to one to insure its structural stability. Designed for high strength and corrosion-resistance service in the 1200-1500 F range, and at higher temperatures under lower stress conditions. Developed in the A-L Research Laboratory at Watervliet, N.Y. in the years of 1940-43, and engine-tested and proved for periods of over 30,000 hours.

S-816 is used currently for turbine blades in two of the production jet engines, also in a number of experimental aircraft and commercial gas turbines. Except for seamless drawn tubing, it is available in practically all forms and shapes in which stainless steels are processed, including hot extrusions.

ALTEMP S-590 was designed for service in the range of 1100-1400 F temperatures where high strength and corrosion resistance are required, and where cost is also a factor. Unlike S-816, which is practically a non-ferrous alloy, S-590 has a chromium-nickel-cobalt-iron base. However, it employs the same molybdenum and tungsten additives, and the same columbium-carbon ratio.

S-590 was developed at the Watervliet Laboratory and field-proved during the same years as S-816. It is available in the same shapes and forms, and is currently being used for turbine blades and wheels in experimental commercial gas turbines.

OTHER GRADES . . . among the many other Super Alloys made by Allegheny Ludlum are V-36, M-252, 19-9 DL, 19-9 DX and Waspaloy.

Do you have a high temperature problem? The services and experience of our Research Laboratories and Technical Staff are completely at your command. *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.*

WSW 8310 R

WRITE FOR INFORMATION

Certified laboratory data on the properties of Allegheny Ludlum high temperature Super Alloy Steels are yours on request.

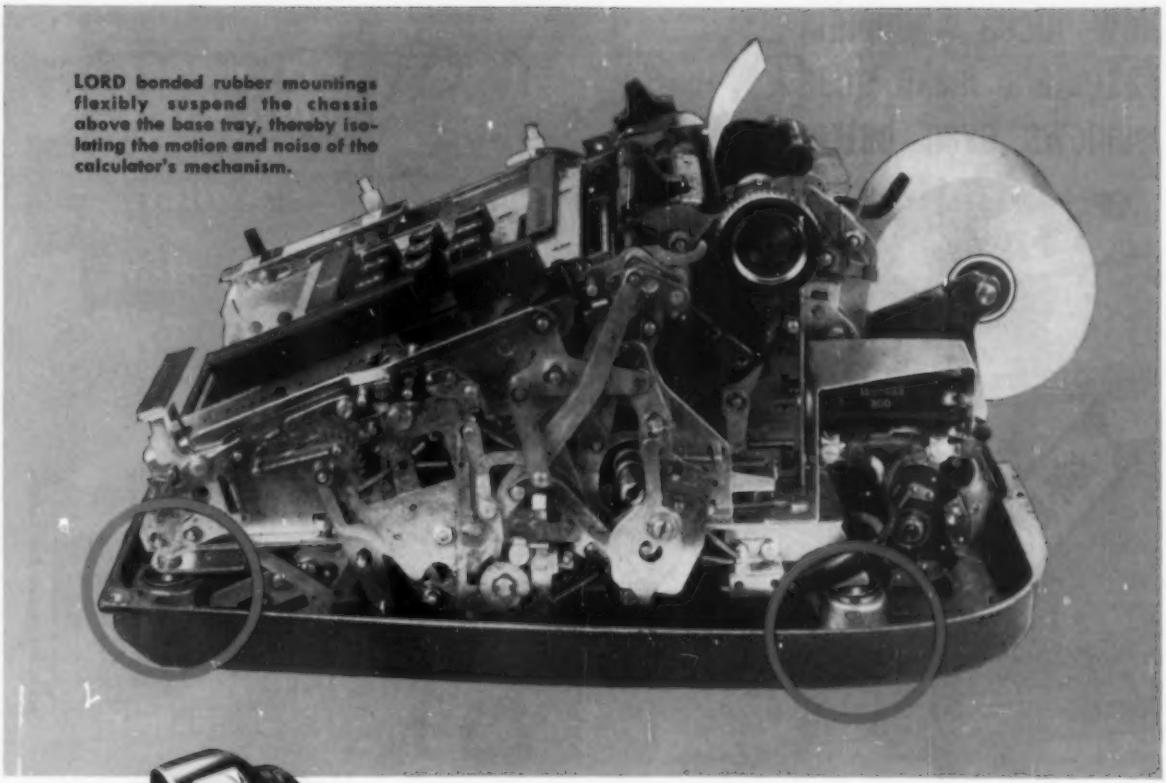
ADDRESS DEPT. PE-92

PIONEERING on the Horizons of Steel

Allegheny Ludlum

Stocks of AL Stainless Steels carried by all Ryerson warehouses

AL® LEADING PRODUCER HIGH-ALLOY STEELS



LORD bonded rubber mountings flexibly suspend the chassis above the base tray, thereby isolating the motion and noise of the calculator's mechanism.

... ...new Victor calculator supported by LORD bonded rubber mountings

LORD tube form mounting used in Victor Calculator has rubber element permanently bonded to inner and outer metal members.

Four LORD bonded rubber mountings concealed beneath the modern styling of this compact, rugged Victor Calculator provide operating quietness by controlling noise-creating vibrations.

Isolating the vibrating machine from the "sounding board" cabinet and desk top, these mountings efficiently control vibration and sound transmission to produce a hushed office atmosphere.

The bonded rubber mountings, specially designed for Victor by LORD engineers, had to be resilient enough to absorb the oscillation of the mechanism yet provide a firm support. This is another example of LORD's success in diversified applications of their engineered vibration control systems.

Whatever your vibration problem, call or write your nearest Field Engineer or the Home Office, Erie, Pa.

ATLANTA, GEORGIA - CEdar 7-1123
BOSTON, MASS. - HAncock 6-9135
CHICAGO, ILL. - Michigan 2-6010
CLEVELAND, OHIO - SHadyside 9-3175
DALLAS, TEXAS - Riverside 1-3392
DAYTON, OHIO - Michigan 8871
DETROIT, MICH. - TRinity 4-2060
LOS ANGELES, CAL. - HOllywood 4-7593
NEW YORK, N. Y. - Circle 7-3326
PHILADELPHIA, PA. - LOcust 4-0147

"In Canada—Railway & Power Engineering Corporation Limited"

LORD MANUFACTURING COMPANY · ERIE, PA.

LORD BONDED RUBBER

designers and producers of bonded rubber products since 1924

How Alcoa Aluminum Fasteners make good windows even better

MEETS AWMA STANDARDS!

You can meet the highest standards of quality and the specifications of the AWMA (Aluminum Window Manufacturers Association) for prime windows of aluminum when you assemble with Alcoa® Aluminum Fasteners. Perfect color match and protection against both galvanic and atmospheric corrosion make for lasting good looks . . . consumer satisfaction. Complete stocks carried by your local Alcoa distributor fill every requirement. He is listed in the Yellow Pages of your telephone directory.

ALCOA ALUMINUM FASTENERS
©ALCOA

Your Guide to the Best in Aluminum Value

THE ALCOA HOUR
TELEVISION'S FINEST LIVE DRAMA
ALTERNATE SUNDAY EVENINGS

Fill out coupon for facts, samples

Aluminum Company of America
2247-H Alcoa Bldg., Pittsburgh 19, Pa.
Gentlemen: Please send complete specification data and samples of Alcoa Aluminum Fasteners.
Name _____
Title _____
Company _____
Address _____

resist even severe vibrations. The screw can be reused repeatedly. The line is now standard with the company and is available in ¼ to 1 in. dia. Cleveland Cap Screw Co., 4444 Lee Rd., Cleveland 28, Ohio.

For more information—
Circle 59, inside back cover

Black Nylon Cap Nuts

These nuts, knurled and slotted, fabricated from black nylon, may be used with rods or screws and also serve as knobs. Available in a range of sizes with 6-32, 8-32, 10-32, and ¼-20 threads. Weckesser Co., Dept. PEN, 5701 Northwest Highway, Chicago 30, Ill.

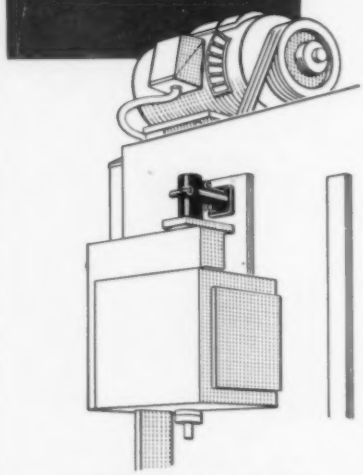
For more information—
Circle 60, inside back cover

Heavy Duty Caster

This 1000 lb capacity caster has been designed to meet military specifications. It has neoprene bearing

(Continued on page 277)

ANGLgear® simplifies switch installation



Drawing based on photo shows ANGLgear drive for rotary limit switch on 75-ton Niagara punch press. ANGLgear's compactness and universal mounting feature helped simplify design of entire switch installation.

Ease of mounting was one of several important reasons why Niagara Machine & Tool Works, Buffalo, N.Y., selected ANGLgear to drive the rotary cam limit switch on its Series E power presses. The fact that ANGLgear can be mounted four different ways makes it easy to design into almost any power transmission system.

Other ANGLgear features that impressed Niagara engineers were compactness, quality construction, and precision gearing. Also ANGLgear cost less than other right-angle drives considered.

If you work with mechanical power transmission, there is an excellent chance that standardized ANGLgear can help you simplify design and reduce costs wherever 90° power takeoff is involved.

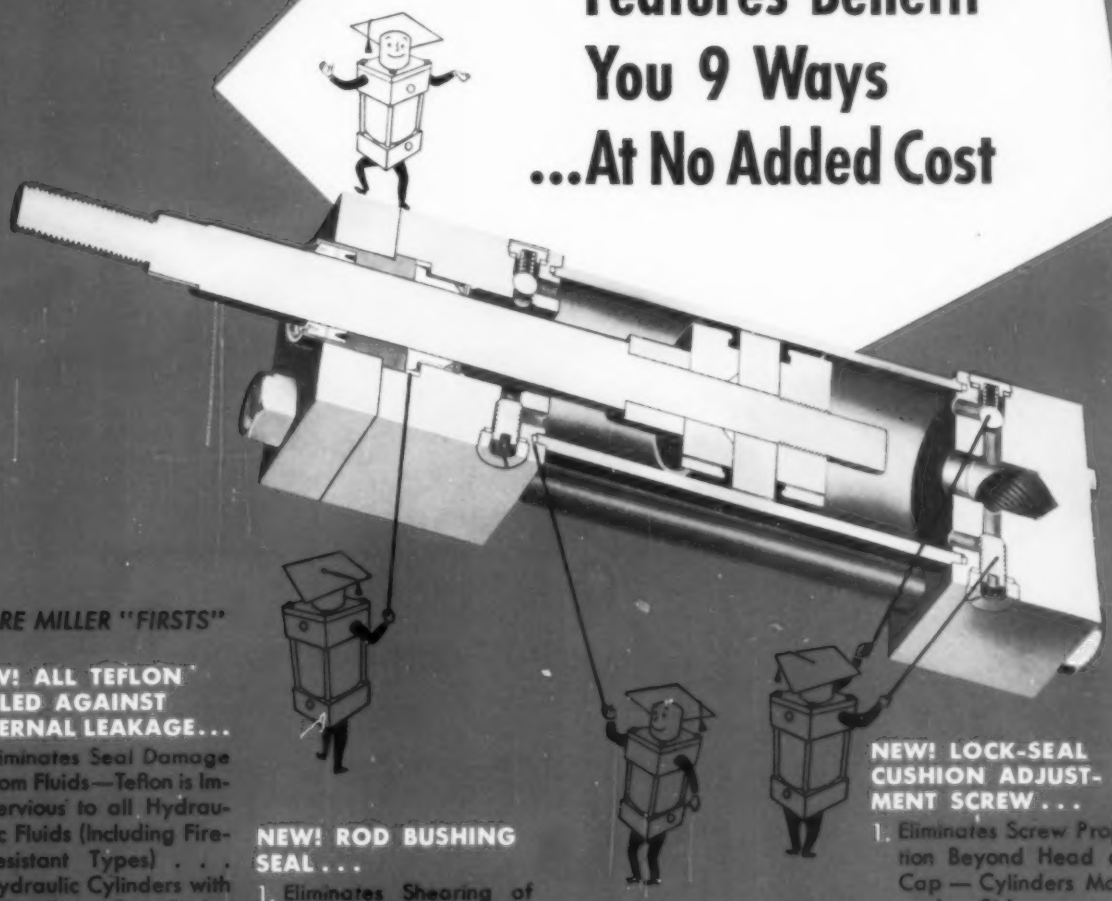
Completely enclosed, permanently lubricated, ANGLgear is available from stock in 1 to 5 hp ratings, with 1:1 or 2:1 gearing, and 2 or 3-way shafting.

See our literature in Sweet's Product Design File or contact your local distributor.

AIRBORNE®
AIRBORNE ACCESSORIES CORPORATION
HILLSIDE 5, NEW JERSEY

Miller®

4 New Hydraulic Cylinder Features Benefit You 9 Ways ...At No Added Cost



MORE MILLER "FIRSTS"

NEW! ALL TEFLON SEALED AGAINST EXTERNAL LEAKAGE...

1. Eliminates Seal Damage from Fluids—Teflon is Impervious to all Hydraulic Fluids (Including Fire-Resistant Types) . . . Hydraulic Cylinders with Teflon Piston Cups Slightly Higher.
2. Eliminates Seal Damage from High Temperatures —Teflon Sealed Cylinders Operate At —100° F. to 500° F.

NEW! ROD BUSHING SEAL . . .

1. Eliminates Shearing of "O" Ring in Re-Assembly
2. Eliminates Extrusion of "O" Ring at Extreme Pressures.

NEW! SHEF SEAL AT TUBING ENDS . . .

1. Eliminates Shearing of "O" Ring in Re-Assembly
2. Eliminates Extrusion of "O" Ring at ANY Pressure—Teflon Sealing Ring is Backed Up by Zero Clearance Metal Shoulder.

NEW! LOCK-SEAL CUSHION ADJUSTMENT SCREW . . .

1. Eliminates Screw Projection Beyond Head and Cap — Cylinders Mount on Any Side.
2. Eliminates Manual Sealing and Locking After Flow Adjustment—Teflon Seal is Self Regulating and Self Locking.
3. Eliminates Accessibility Problems—Cushion Screw Interchangeable with Ball Check Position—Adjustable Through Small Wrench Hole Drilled in Interfering Machinery.

du Pont trademark for its tetrafluoroethylene resin

Copyright 1957—Flick-Reedy Corporation

Turn Page For Cross Section Of SHEF SEAL

S SHEAR PROOF
H HEAT PROOF
E EXTRUSION PROOF
F FLUID PROOF
SEAL
Teflon Pressure Energized
Hydraulic Cylinder Tubing End Seal
PAT. APPLIED FOR

OTHER MILLER QUALITY FEATURES

- Case-Hardened Chrome Plated Piston Rod
- Rust Resistant Surfaces
- Teflon Oil and Dirt Wipers
- Interchangeable Square Design

Miller - FLUID POWER DIVISION
FLICK-REEDY CORPORATION

2002-04 N. Hawthorne Ave., Melrose Park, Ill.

AIR AND HYDRAULIC CYLINDERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS • BOOSTERS

Miller®

Announces a New Space and Price Saving Hydraulic Cylinder Line

SAVE UP TO 76% OF COST

Heavy Duty Model LH—Same Size As Ordinary Gasket Type Square Design Low Pressure Cylinders			
BORE	NORMAL RATINGS	NON-SHOCK INTERMITTENT RATINGS	YOU SAVE THIS % IN PRICE OVER STANDARD 2000-3000 PSI CYLINDERS
1½"	1500 PSI	2500 PSI	27%
2	1500	2500	27%
2½	1000	1500	28%
3¼	1500	2500	32%
4	1000	1500	35%
5	800	1200	37%
6	800	1200	43%
8	500	800	50%
10	500	800	71%
12	500	800	76%
14	500	800	*Not Available in 2000-3000 PSI*

MORE MILLER "FIRSTS"

Miller®

Announces 50% More Power Per Cylinder Dollar

with Extra Heavy Duty

3000-5000 PSI MODEL H

HYDRAULIC CYLINDERS

Same Price and Mounting Dimensions as Miller 2000-3000 PSI Hydraulic Cylinders.

BOTH LINES MADE POSSIBLE BY SHEF SEAL

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Miller - FLUID POWER DIVISION
FLICK-REEDY CORPORATION

AIR AND HYDRAULIC CYLINDERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS • BOOSTERS

OTHER MILLER QUALITY FEATURES

- All Teflon Sealed Against External Leakage—Teflon Cups Extra
- Case-Hardened Chrome Plated Piston Rod
- Shear Proof Rod Bushing Seal
- Ball Check Interchangeable with Self Sealing and Locking Cushion Adjustment
- Rust Resistant Surfaces
- Teflon Oil and Dirt Wipers

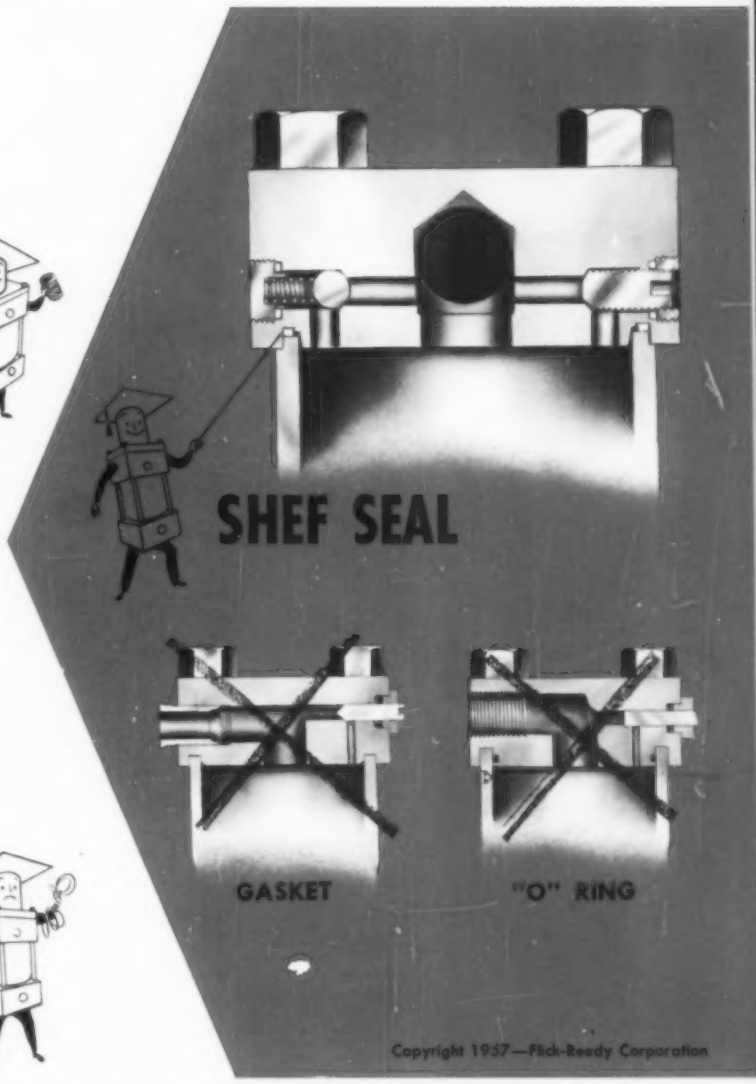
S SHEAR PROOF
H HEAT PROOF
E EXTRUSION PROOF
F FLUID PROOF
SEAL

Teflon Pressure Energized
Hydraulic Cylinder Tubing End Seal
PAT. APPLIED FOR

SHEF SEAL Obsoletes All Other Hydraulic Cylinder End Seals . . . *at no added cost*

HAS EVERY ADVANTAGE

1. Pressure Energized—Sealing Effectiveness Increased with Pressure.
2. Zero Metal-To-Metal Clearance at all Pressures Gives You Perfect Seal Backup. Sealing Ring Cannot Extrude.
3. Simplified Servicing. No "Blind" Assembly. Sealing Ring Cannot Shear.
4. Teflon* Sealing Ring Withstands All Hydraulic Fluids at Temperatures from —100° F. to 500° F.
5. Head and Cap Axial Movement Does Not Destroy Sealing.
6. Allows Air Bleed In Head and Cap for Remote or Automatic Bleeding.
7. One Sealing Ring Cross Section Dimension For All Cylinder Sizes—Supplied On Convenient Spools.
8. Zero Metal Backup Clearance Eliminates Dangerous Leaks and Spurts of Fluid Due To Seal Failure.

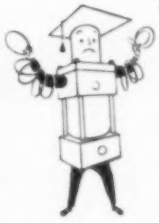


NONE OF THESE DISADVANTAGES

GASKET CONSTRUCTION

1. Unpredictable Results—Leaks and Blows Even at Low Pressures.
2. Outlawed by J.I.C. Eight Years Ago.
3. Seal Failure Causes Dangerous Leaks and Spurts of Fluid. Creates Unnecessary Fire and Safety Hazard.

"O" RING CONSTRUCTION



1. High Pressures and Shock Loads Expand Tubing—Increase Clearance and Cause Extrusion.
2. Blind Assembly Can Shear Sealing Ring—Difficult Servicing.
3. Seal Failure Causes Dangerous Leaks and Spurts of Fluid. Creates Unnecessary Fire and Safety Hazard.
4. Requires Large Inventory of "O" Rings
   —For Servicing Variety of Cylinder Bores.
   —For Special Synthetic Rubber Compounds To Meet Ever Changing Fluid and Temperature Needs.

*du Pont trademark for its tetrafluoroethylene resin.

SHEF SEAL—*Another Miller "First"*

Copyright 1957—Flick-Reedy Corporation

When you buy Miller ... You buy extra years of worry-free Cylinder performance ...at competitive prices

S SHEAR PROOF
H HEAT PROOF
E EXTRUSION PROOF
F FLUID PROOF
SEAL
Teflon Pressure Energized
Hydraulic Cylinder Tubing End Seal
PAT. APPLIED FOR

OTHER MILLER QUALITY FEATURES

- All Teflon Sealed Against External Leakage—Teflon Cups Extra
- Case-Hardened Chrome Plated Piston Rod
- Shear Proof Rod Bushing Seal
- Ball Check Interchangeable with Self Sealing and Locking Cushion Adjustment
- Rust Resistant Surfaces
- Teflon Oil and Dirt Wipers

Miller - FLUID POWER DIVISION
FLICK-REEDY CORPORATION

Turn Page For More About MILLER

AIR AND HYDRAULIC CYLINDERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS • BOOSTERS

All Teflon Sealed —Perfect Sealing for Hydraulic Cylinders

HAS EVERY ADVANTAGE...

Teflon—As Static and Dynamic Seals

1. Impervious to Every Hydraulic Fluid Including Fire-Resistant Types.
2. Seals Perfectly in Cylinders at Temperatures from —100° F. to 500° F.
3. Can Be Molded Into Shapes That Have Zero Leakage—Hold Pressure Indefinitely.
4. With Proper Design of External Seal Cavities, Teflon Can Be Included *Without* Increasing Prices. Miller Provides Teflon for all External Seals at Prices Competitive with Ordinary Cylinders. Leather Internal Piston Cups are Standard (Teflon Cups Extra).

Copyright 1957—Flick-Reedy Corporation
Printed in U.S.A.

du Pont trademark for its tetrafluoroethylene resin.

When you buy Miller
You buy extra years
of worry-free
Cylinder performance
...at competitive prices

NONE OF THESE DISADVANTAGES

Synthetic Rubber— As Static and Dynamic Seals

1. Unsatisfactory Except When Used With A Limited Range of Hydraulic Fluids.
2. Even Uncontrollable Changes in Fluid Additives Often Destroy Seal.
3. Specific Compounds Needed for Compatibility with Specific Fluids Normally Used Today.
4. Normal Temperature Range Limited to 0° F. to 130° F. Slightly Reduced Life When Operated at 130° F. to 150° F. Greatly Reduced Life at 150° F. to 250° F.
5. External Leakage Causes Fire and Safety Hazards When Temperature or Fluid Destroys Seals.
6. "U" Type Seals Without Mechanical Retainer at Mid-Section Frequently "Roll" and Lose All Sealing Ability.

Resin Impregnated Leather— As Dynamic Seals Only

1. Is Compatible with Many—But Not All—Hydraulic Fluids and Additives Including a few Fire-Resistant Types.
2. Normal Temperature Range Limited to —60° F. to 130° F. Slightly Reduced Life When Operated at 130° F. to 150° F. Substantially Reduced Life at 150° F. to 250° F.
3. External Leakage Causes Fire and Safety Hazards When Temperature or Fluid Destroys Seals.
   Miller Uses Leather Piston Cup Seals for Internal Sealing... Standard Price (Teflon Cups Extra).

Piston Rings— As Dynamic Internal Seals

1. Most Piston Rings Allow Some Leakage.
2. Allow "Slip" or "Drift" of Piston Due To Leakage—Unsatisfactory for Many Applications.
3. Allow Varying Feed Rates Due To Leakage Because Of Viscosity Change During Startup—Unsatisfactory for Most Multiple and Automated Operations.
4. Allow Some Pressure Loss.
5. Chips and Dirt Enter Space Between Piston and Tube Causing Scoring —Especially During Startup.

All Teflon Sealed—*Another Miller "First"*

OTHER MILLER QUALITY FEATURES

- All Teflon Sealed Against External Leakage—Teflon Cups Extra
- Case-Hardened Chrome Plated Piston Rod
- Shear Proof Rod Bushing Seal
- Ball Check Interchangeable with Self Sealing and Locking Cushion Adjustment
- Rust Resistant Surfaces
- Teflon Oil and Dirt Wipers

S SHEAR PROOF
H HEAT PROOF
E EXTRUSION PROOF
F FLUID PROOF
SEAL
Teflon Pressure Energized
Hydraulic Cylinder Tubing End Seal
PAT. APPLIED FOR

Miller FLUID POWER DIVISION
FLICK-REEDY CORPORATION
2002-04 N. Hawthorne Ave., Melrose Park, Ill.

AIR AND HYDRAULIC CYLINDERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS • BOOSTERS

seals to protect swivel and wheel bearings from steam, water, chemicals, dirt and other contaminants. The caster has a four-position swivel lock for improved steering and uses two 8x2 in. rubber-tired wheels equipped with tapered roller bearings. For hand or powered heavy duty equipment. The Colson Corp., Elyria, Ohio.

For more information—
Circle 61, inside back cover

Screw Head Hose Clamps

Collared screw heads are provided on these stainless steel hose clamps. Series C-S keeps the screw driver from slipping. Series S does not limit the size of the screw driver. Both series are available in all sizes. Wittek Mfg. Co., 4305-37 W. 24 Pl., Chicago 23, Ill.

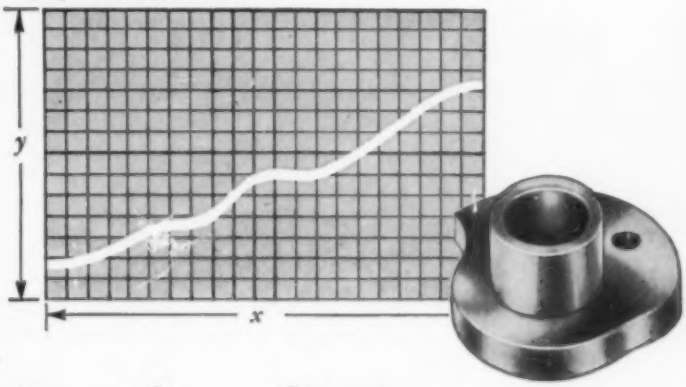
For more information—
Circle 62, inside back cover

Wide Range Milling Spindle

Belt arrangement provides spindle speeds of 130, 195, 300, 460, 705, 1060, 1640, and 2500 rpm. Full power to the spindle is said to be maintained even on lowest speeds. Drive is a 2 hp, 1200 rpm motor. Absence of gears permits quieter operation. Belts are easily removed or adjusted to change speed ratios. The spindle nose is a No. 40 taper. Tur-

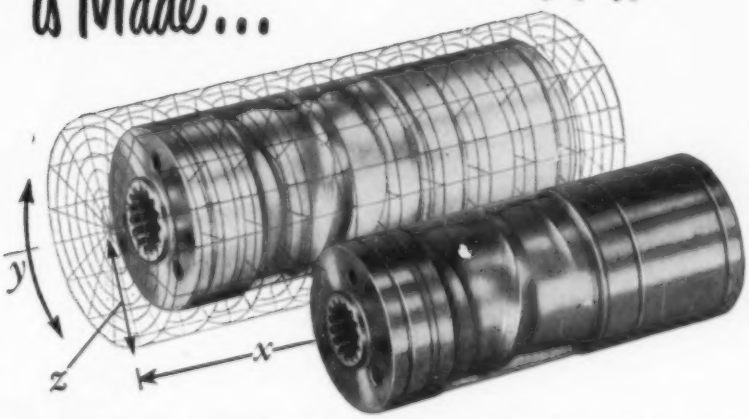
(Continued on page 280)

Here's How a 2 Dimensional Cam is Made...



Here's How a 3 Dimensional Cam is Made...

$z = f(x,y)$



HERE'S HOW YOU CAN GET THE GRAPHIC STORY OF CAMS THAT "COULDN'T BE BUILT"—*BUT WERE DELIVERED BY PARKER!*

Send today for the new, fact-filled Parker folder—discover how Parker can engineer and build three dimensional cams with an infinite number of precisely machined stations to serve as the "brains" for a wide range of automatic operations.

THE PARKER-HARTFORD CORPORATION
CAM DIVISION
FRANKLIN AVENUE • HARTFORD, CONNECTICUT
by Parker

Flexon®

bellows and bellows assemblies

design and application briefs

How Honeywell Uses Bellows for Positive Temperature Control with Their Adatrol* Gas Valve

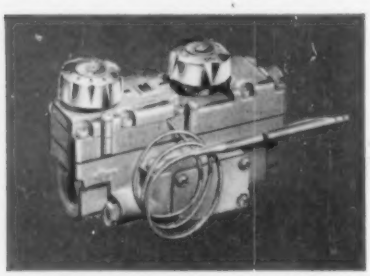
View in Flexonics laboratories showing mass spectrometer being used to test bellows for leakage.

HONEYWELL

The V5153 Adatrol* Thermostatic Gas Valve, manufactured by Minneapolis-Honeywell Regulator Company is a 100% shut-off gas cock and a bellows-actuated snap-acting thermostat for gas heating devices.

How it Works

When the pilot flame is normal, the thermo-electric power generated by an appropriate pilot burner-thermocouple combination energizes an



Adatrol* Thermostatic Gas Valve.

electro-magnet in the Pilotstat to hold the Pilotstat valve open. However, should the pilot flame become inadequate for proper ignition of the main burner, the thermo-electric current quickly drops off causing the valve to close and block gas flow to the pilot and main burner.

Flexon Bellows is the Heart of the Control

Automatic temperature control is provided by the snap-acting thermostat section that incorporates a Flexon Bellows Assembly. The temperature sensing element (a bulb) is connected to the internal actuating element (a bellows) by a capillary tube. The bulb-tubing-bellows combination is completely filled with a hydraulic temperature sensitive liquid. Changing temperature in the area surrounding the bulb creates a changing pressure in the bellows, which actuates the valve.

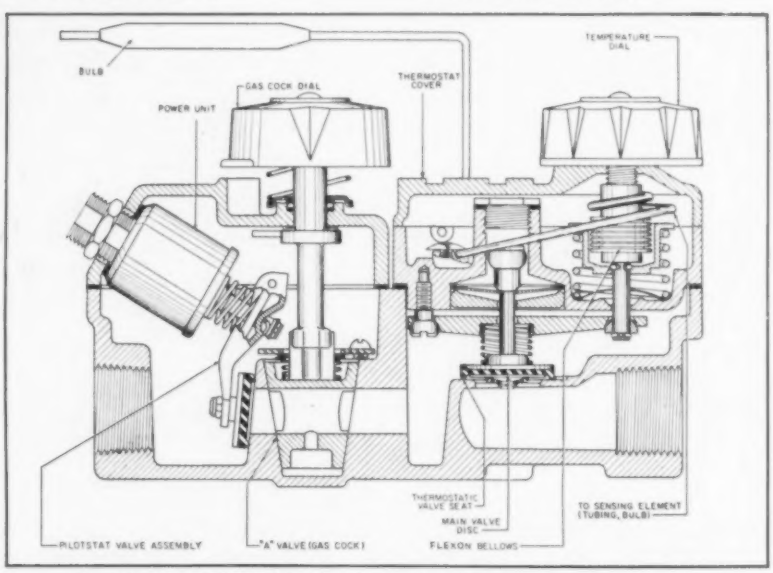
Due to the small percentage of total fill in the bellows and capillary, the control is not appreciably affected by temperatures other than at the bulb location. Because it is a solid fill, instrument calibration is unaffected by altitude changes.

Why Flexon Bellows Are Used

Minneapolis-Honeywell uses Flexon Bellows Assemblies in the Adatrol* Valve to take advantage of Flexonics Corporation's facilities and bellows manufacturing know-how. Flexonics' application engineers are cost conscious, skilled in recommending the bellows or bellows assemblies that provide the performance required by the device at the lowest price consistent with these requirements.

Engineering Assistance

The Flexonics Application Engineering Staff will be pleased to assist you in your bellows application problems. For specific recommendations send an outline of your requirements. For your bellows reference file, write for the Flexon Bellows Design Guide.



Cross section of the Adatrol* unit showing the arrangement of elements.

*Adatrol is the trademark of Minneapolis-Honeywell Regulator Co.

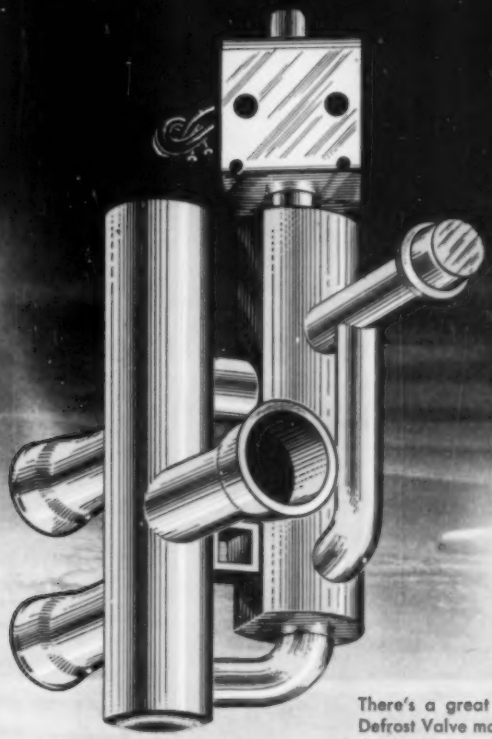
Flexonics® Corporation
BELLOWS DIVISION

1351 S. Third Avenue, Maywood, Illinois

In Canada: Flexonics Corporation of Canada, Limited, Brampton, Ontario

Also Manufacturers of Rubber and Metal Hose Assemblies • Expansion Joints • Aircraft Components

EXPERTS SAID: *"It can't be done"*



There's a great future ahead for this Heat Pump Defrost Valve made by CHATLEFF VALVE & MFG. CO., Austin, Texas. And Chase helped pave the way!

. . . but CHATLEFF and CHASE did it!

The heart of a heat pump is this refrigerant transfer valve—and it's tough to produce! But Chase technicians helped the Chatleff Valve Co. solve these problems:

To give the necessary ruggedness, corrosion-resistance and high density, Chase supplied a specially controlled alloy of leaded brass tube shapes. To cut scrap loss and machine time, they were made to extremely close tolerances. And all tube shapes received a closely controlled anneal to prevent subsequent warping. To minimize distortion, Chase created ideal conditions for welding alloys of varying thicknesses, a severe operation.

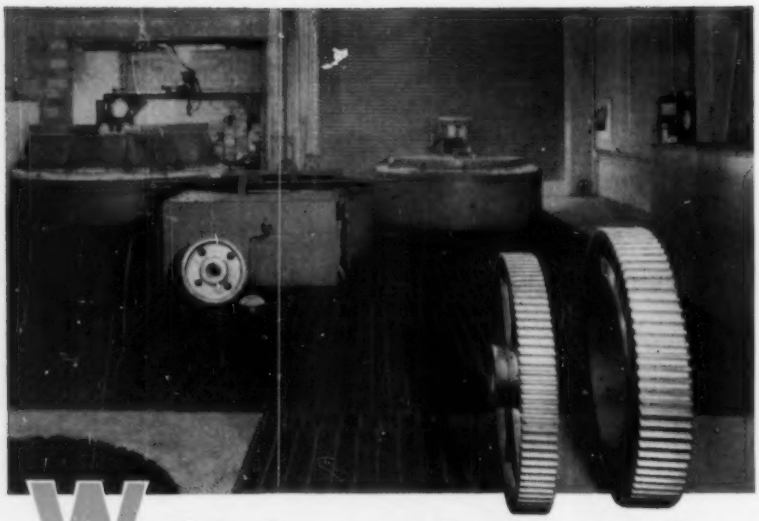
In fact, Chase did what experts called "impossible": helped set up a single furnace-brazing operation for 13 simultaneous welds! Now this Chatleff valve body is being mass-produced as a single unit . . . with great efficiency and economy. Maybe Chase can help *you*, too!

Bring your production problems to... Chase

BRASS & COPPER CO.
WATERBURY 20, CONNECTICUT
SUBSIDIARY OF KENNECOTT COPPER CORPORATION

The Nation's Headquarters for Brass, Copper and Stainless Steel

Atlanta Baltimore Boston Charlotte Chicago Cincinnati Cleveland Dallas Denver Detroit Grand Rapids Houston Indianapolis Kansas City, Mo. Los Angeles Milwaukee Minneapolis Newark New Orleans New York (Maspeth, L.I.) Philadelphia Pittsburgh Providence Rochester St. Louis San Francisco Seattle Waterbury



World's largest Radiant Tube Pit-type Carburizer installed at

...more precise heat treatment for larger gears

• New heat-treating equipment, including the largest radiant tube pit-type gas carburizing furnace ever built, has recently been installed in the Pittsburgh plant of our subsidiary, Pittsburgh Gear Company. These new additions to BRAD FOOTE's extensive heat-treating equipment provide facilities for the most advanced techniques in deep case carburizing and hardening in controlled atmospheres.

• The new carburizer can handle gears or machine parts up to 6 feet long, 6 feet wide and up to 8500 pounds in weight. In addition to its size, the new equipment has an unusual ability to control carbon penetration, giving extremely precise control of the depth of surface hardening.

• Special heat-treating equipment, like this new carburizer, allows BRAD FOOTE to impart the precise metallurgical characteristics which make for longer wear, shock resistance and freedom from distortion in gears of all sizes and types. And BRAD FOOTE heat-treating is under the supervision of metallurgists with long experience in the special problems of the gear industry.

• Whether you want one gear or ten thousand, BRAD FOOTE's extensive facilities and specialized skills are at your disposal. Send us the specification on your next problem job for quotation. No obligation, of course.

BRAD FOOTE

BRAD FOOTE MAKES

Spur • Bevel
Helical • Spiral Bevel
Herringbone
Zerol • Worms
Worm Gears • Reducers
Transmissions

BRAD FOOTE GEAR WORKS, INC.

1310 South Cicero Avenue • Cicero 50, Illinois
Bishop 2-1070 • Olympic 2-7700 • TWX: CIC-2856-U

subsidiaries

AMERICAN GEAR & MFG. CO.
Phone: Lamont 920
Lemont, Illinois

PITTSBURGH GEAR COMPANY
Phone: SPalding 1-4600
Pittsburgh 25, Pennsylvania

chan Follower Machine Co., P.O. Box 6055, Dearborn, Mich.

For more information—
Circle 63, inside back cover

ENGINEERING DEPT. EQUIPMENT

Speed Measurements

These variations of the tachoscope, used for speed measurements and suitable for everyday use on routine tests, include the basic instrument equipped with 1: 10 ratio gear box. With this unit, it is possible to read 0-10, 0-100, and 0-1000 on the dials of the revolution counter. Another is equipped with a special handle and both 6 in. and 12 in. dia wheels, for accurate measurements of length or feet per minute. It can also be used for all rotational speed measurements.

Instruments are accurate to 0.1%. The minute dial of the watch is calibrated in seconds and fifths of seconds and also in hundredths of a minute, readable to 0.002 min. James G. Biddle Co., 1316 Arch St., Philadelphia 7, Pa.

For more information—
Circle 64, inside back cover

Makes Large Photocopies

This outfit, which makes photocopies up to 20 in. wide by any length, is now available for copying large sketches, blueprints. The unit consists of an automatic continuous printer with shutter-type light control and an automatic, continuous proc-

(Continued on page 284)

Simplicity Model S-200 Asphalt Plant recently delivered to Ben M. Hogan & Company, Little Rock, Ark. This is Hogan's fourth Simplicity Plant, and is producing well over 100 tons of asphalt mix per hour.

"4 times around the world—that's how far we estimate a Standard Steel ring will travel as an integral part of a Simplicity Asphalt Plant"

"In 40 years of service we estimate that a bull gear and tire on the rotating dryer drum of a Simplicity Asphalt Plant travels at least 100,000 miles to make four million tons of asphalt without defecting. These and other components of our asphalt plants are forged by Standard Steel Works.

"But we are not only justly proud of the durability of our products, thanks in part to Standard, but also of the service we render our many customers—both in terms of delivery and of maintenance. And that's where Standard Steel Works is of greatest value to us. A special delivery arrangement with Standard Steel Works, plus their personalized service, helps us maintain superior service to our customers."

Frankly, we feel we deserve this fine compliment from Mr. Whitfield. We know how important it is for *our* customers to keep *their* customers satisfied. That's why we take a special interest in their needs and keep letting our men in the shop know the importance of the role they play in helping our customers maintain a favorable competitive position.

Why not invite us to discuss your casting, forging and weldless ring needs with you. It won't cost you anything, and we can probably show you ways in which our service can save you money. Write Dept. 4-H.

"About five years ago we furnished a replacement 8 ft. x 15 ft. dryer drum to a customer whose dryer had been in service on a Simplicity Asphalt Plant for 25 years. The steel tires and bull gear of the old dryer showed no signs of wear and were used in the new drum. Those rings were supplied to us by Standard Steel Works. That's why we know the quality of Standard's rings is as good as the service they render us," *says Harlan Whitfield, of The Simplicity System Company, Chattanooga, Tenn.*

Standard Steel Works Division

BALDWIN · LIMA · HAMILTON

BURNHAM, PENNSYLVANIA Rings • Shafts • Car wheels • Gear blanks • Flanges • Special shapes

Fastener Facts

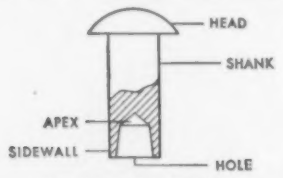
by Henry Peterson, Chief Engineer — Judson L. Thomson Mfg. Co.

DESIGN PRODUCTION & PURCHASING DATA

FASTENING WITH SEMI-TUBULAR RIVETS

WHY RIVETS?

You specify rivets when you want strong, permanent fastening at low cost. However, secure fastening is not their only function. You can also use them as fulcrums, pivots, cam followers, electrical contacts, studs, stops and in many other applications.



Typical semi-tubular rivet

WHY SEMI-TUBULAR RIVETS?

You specify semi-tubular rivets when you want to combine the high shear and compression strength of solid rivets with low-cost, high-speed fastening. The required strength is inherent in the design of Thomson Semi-Tubular Rivets.

Shallow holes in solid shanks distinguish semi-tubular rivets from other types. The hole is seldom deeper than shank diameter. Its depth is determined by clinch requirements of specific applications. A general rule is to select a rivet with length equal to the thickness of the materials *plus* 55% of the diameter of the shank. A Thomson engineer can quickly specify the correct rivet length and hole depth for any particular semi-tubular riveting application.

Semi-tubular rivet applications call for pre-drilled or punched holes in the materials to be fastened: metals, plastics, wood, ceramics and other hard materials. The size of the prepared holes is an important design consideration. When holes are too small, rivets choke. When too large, rivets buckle. To avoid either error, make sure that each hole is about 7% larger than the maximum shank diameter of the rivet. In most cases, the setting process causes shank expansion sufficient to fill the hole. Again, Thomson engineering is at your service to help you match rivet and hole sizes.

High shear strength of semi-tubular rivets is further assured by Thomson production methods. All Thomson Semi-Tubular Rivets are made from specially prepared wire by the cold heading or upsetting process. This results in fasteners with the uniform structure and *inherent strength of forgings* . . . properties not achieved by screw-machine rivet production.

Standard materials used to produce Thomson Semi-Tubular Rivets include aluminum, brass, copper, nickel-silver, low-carbon steel and stainless steel. For special electrical and electronic contacts, coin silver, fine silver, palladium and other precious metals may be specified.

Finishing to specifications is another service of interest to design engineers. Rivets can be plated with brass, cadmium, copper, nickel, tin, zinc, etc. Morever, they can be oxidized or finished in japanned colors to match the original equipment or product.

Low fastening costs result from the application of Thomson Semi-Tubular Rivets with automatic rivet-setting machines. The low cost of rivets, as compared with most other fasteners, combined with high machine speeds invariably leads to production line economies. Machines are low in initial cost and require little maintenance. Furthermore, they can be operated by unskilled labor.

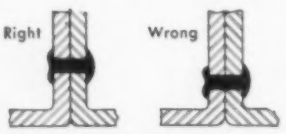
FLOOR-TYPE FOOT-OPERATED | FLOOR-TYPE MOTOR-OPERATED

HIGH PRODUCTION RIVET-SETTING MACHINES

Thomson has developed more than 200 styles of modern, high speed machines which can be adapted to innumerable fastening jobs. These machines are divided into three basic models: floor type with foot-pedal operation, floor type with motor operation, and bench type with motor operation. All permit automatic hopper feed for maximum speed, and some motor driven floor models are equipped for multiple rivet-setting.

Special work-handling devices accelerate riveting operations. Radial or turret feeds are common accessories for machines geared to high-production fastening of parts, as are all types of special loading fixtures. Thomson selects the proper machine to do your job most efficiently and custom-tools it to fit your fastening requirements.

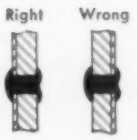
DESIGN PRACTICES



Clearing Corners

Allow plenty of room between hole and flange for anvil clearance.

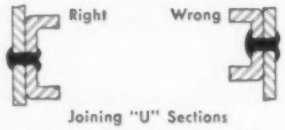
Joining Thick and Thin Sections



Insert rivet from thin-gage side and clinch against heavier section.

Avoid Over-Sized Holes

When holes are too large, rivet may buckle during clinching operation.



Joining "U" Sections

The wider the channel, the easier the riveting operation. Clinching inside "U" leaves driving and feeding mechanisms out in the open.

DESIGN & ENGINEERING SERVICE

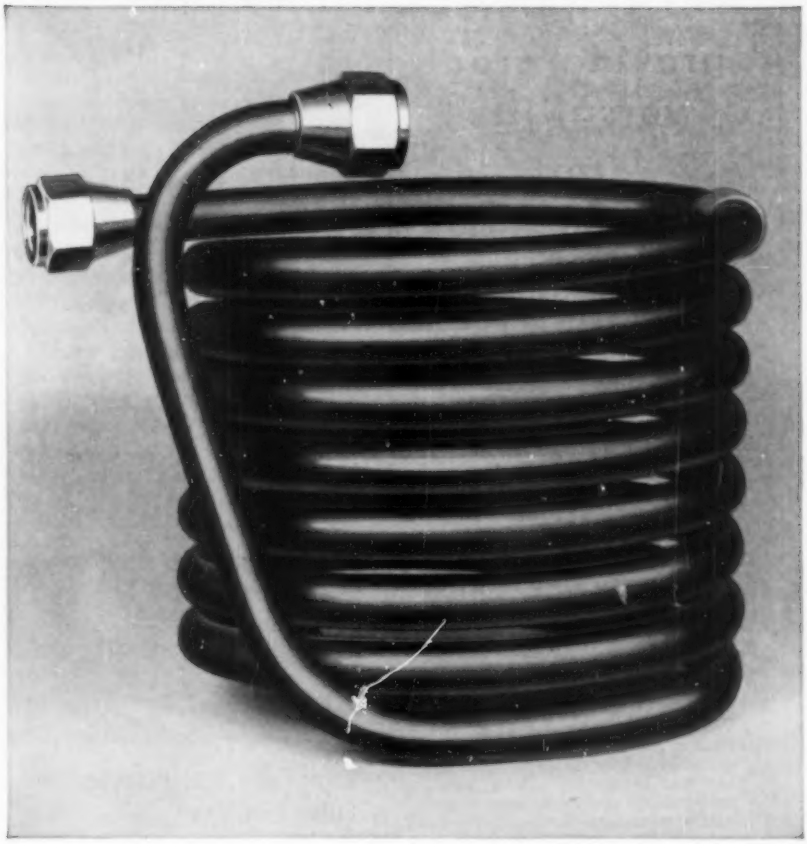
We will gladly evaluate your fastening problems at little or no cost. Contact us while designs can still be modified for lowest cost fastening method. Simply send sketches, prints, or preferably samples of actual work.

FREE "FASTENER FACT FILE"

Be one of the first to profit from our new manual on all phases of riveting. It covers rivet types, applications, materials, finishes, and other factors that determine selection of the right design, rivet and machine for cutting fastening costs. Request your copy today. Write Judson L. Thomson Mfg. Co., Dept. C, Waltham 54, Massachusetts.

JUDSON L. THOMSON MFG. CO., WALTHAM 54, MASS.

How Bundy helped Eaton designers with oil cooler for hydraulic power steering



Oil-cooler coil for power-steering unit stands only 4¾" high, yet contains over 11 feet of ½" x .035" Bundyweld Tubing. The inside diameter of the coil measures just 4.88". This I.D. dimension is held to +⅛" tolerance. Ends are double-flared with fittings attached.

A heavy-duty power-steering pump made by Eaton Manufacturing Company is used in a closed system. Since this pump is driven by the fan belt, the unit must be mounted near the engine. But in this location, its hydraulic fluid absorbs engine heat. Problem: Cool the oil, and do it in limited space. For expert help, Eaton designers checked with Bundy®.

In a cooperative design effort, Eaton and Bundy engineers surrounded the hydraulic reservoir with this 4¾"-high coil of Bundyweld Tubing, to provide additional prime cooling surface. As hydraulic fluid is pumped through some 11 feet of tubing, it loses heat. Temperature reduction during each cycle averages between 25° and 35° F.

Because the coil is made from Bundyweld, it will stand up under severest operating conditions; deliver years of trouble-free service. Bundy's modern fabrication facilities mass-produce the part – coil the tubing, attach the fittings, and double-flare the tubing ends.

Customers in many industries have learned to depend on Bundy for design experience and know-how, as well as the finest in small-diameter tubing. An exclusive process, shown below, has made Bundyweld the standard of the automotive and refrigeration industries. *It's used on 95% of today's cars, in an average of 20 applications each.*

If you are looking for moneysaving answers to tubing design or fabrication questions, you'll find them at Bundy. Call, write or wire us today!

BUNDY TUBING COMPANY • DETROIT 14, MICHIGAN

WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING. AFFILIATED PLANTS IN AUSTRALIA, ENGLAND, FRANCE, GERMANY, AND ITALY

Bundyweld starts as a single strip of copper-coated steel. Then it's
. . . continuously rolled twice around laterally into a tube of uniform thickness and passed
through a furnace. Copper coating fuses with steel. Result . . .
SIZES UP TO ¼" O.D.
Bundyweld, double-walled and brazed through 360° of wall contact.
NOTE the exclusive Bundy-developed beveled edges, which afford a smoother joint, absence of bead, and less chance for any leakage.
THERE IS NO REAL SUBSTITUTE FOR
BUNDYWELD® TUBING
DOUBLE-WALLED FROM A SINGLE STRIP

Acme SPECIAL ATTACHMENTS provide great versatility for CONVEYOR CHAINS

Acme Precision conveyor chains are easily adapted to special requirements by the use of stock or specially designed attachments. Possibilities for modification of Acme standard chains are practically endless. In all adaptations, Acme engineers are skilled in retaining as many standard parts as possible to reduce costs.

Most attachments are in reality special plates which take the place of standard chain plate and are stamped from dies in production quantities. Attachments in smaller lots can be hand machined, cast, bent or welded to your specifications.

Whether you use a simple extended pin design or more elaborate attachments used for timing and motioning special conveyor lines, Acme engineers are ready to design practical applications for you.

All Acme conveyor attachments available in stainless steel for the packaging and food industries. Write our engineering department.

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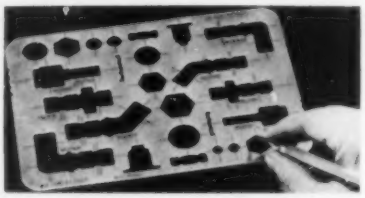
essor. Both are stainless steel covered and have heavy gage steel bases. Available individually or as a complete unit.

The unit requires no special equipment or darkroom. Eliminates chemical fumes, washing, fixing, drying. Makes from 60 to 90 sharp copies per hr, one or two-sided. Reproduces from all colors. Operates on 110 v a-c. General Photo Products Co., Inc., General Photo Bldg., Chatham, N. J.

For more information—
Circle 65, inside back cover



Templates for Flareless Tube Fittings

Five drafting templates for layout of MS-type flareless tube fittings have cutouts in $\frac{7}{16}$ and $\frac{5}{16}$ in., $\frac{1}{4}$ and $\frac{3}{8}$ in., $\frac{1}{2}$ in., $\frac{5}{8}$ in., and $\frac{3}{4}$ in. sizes. Templates are made of 0.025-in. vinyl plastic, amber-coated to reduce eyestrain. E. F. Twomey Co., Inc., P. O. Box 15913, Los Angeles 15, Calif.

For more information—
Circle 66, inside back cover

Universal-Type Bow Instrument

Three sizes of aluminum bow instruments make circles $\frac{1}{8}$ to 14 in. dia, $\frac{3}{32}$ to 10 in. dia, and $\frac{1}{16}$ to 5 in. dia. Balanced, easy to hold, lightweight, non-glare in finish. Boxed with plastic tube, holding extra leads, divider needle, and spare parts. Alvin Co., Windsor, Conn.

For more information—
Circle 67, inside back cover

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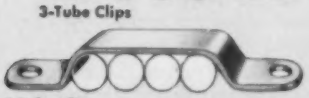
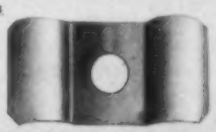
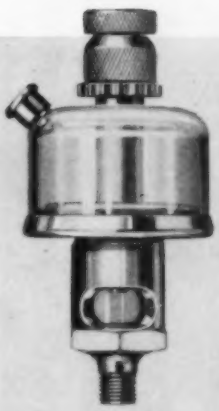
3-Tube Clips



4-Tube Clips



Double Clips — Wing Type



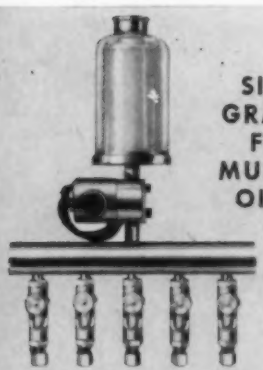
SIGHT GRAVITY FEED OILERS

Rate of oil flow regulated by needle valve, directly observed through sight glass in stem.

Shut-off knob does not affect needle valve adjustment. Visible oil supply. Non-breakable. Tops in convenience and dependability, at low cost. Style NFU—No. 3602-A.

GEAR CASE GAUGES

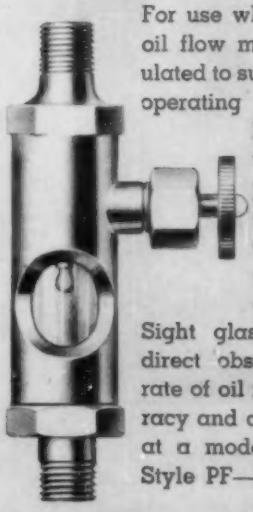
This oil gauge plug permits instant checking of oil level within a transmission or gear case. For use where construction permits insertion in tapped hole. A valuable addition to any such equipment — at very low cost. Style BW—No. 4042.



SIGHT GRAVITY FEED MULTIPLE OILERS

This one unit replaces 3 to 8 individual oilers. Maximum practicality in a small central lubrication system. Positive cut-off during idle periods. Individual vibration-proof needle valve adjustments. With solenoid control (Illustrated): Style MDS—No. 4685-A. Without solenoid: Style MD.

SIGHT GAUGES



For use where rate of oil flow must be regulated to suit changing operating conditions. Needle valve permits extremely accurate adjustment of oil feed. Sight glass provides direct observation of rate of oil flow. Accuracy and convenience at a moderate price. Style PF—No. 4290.

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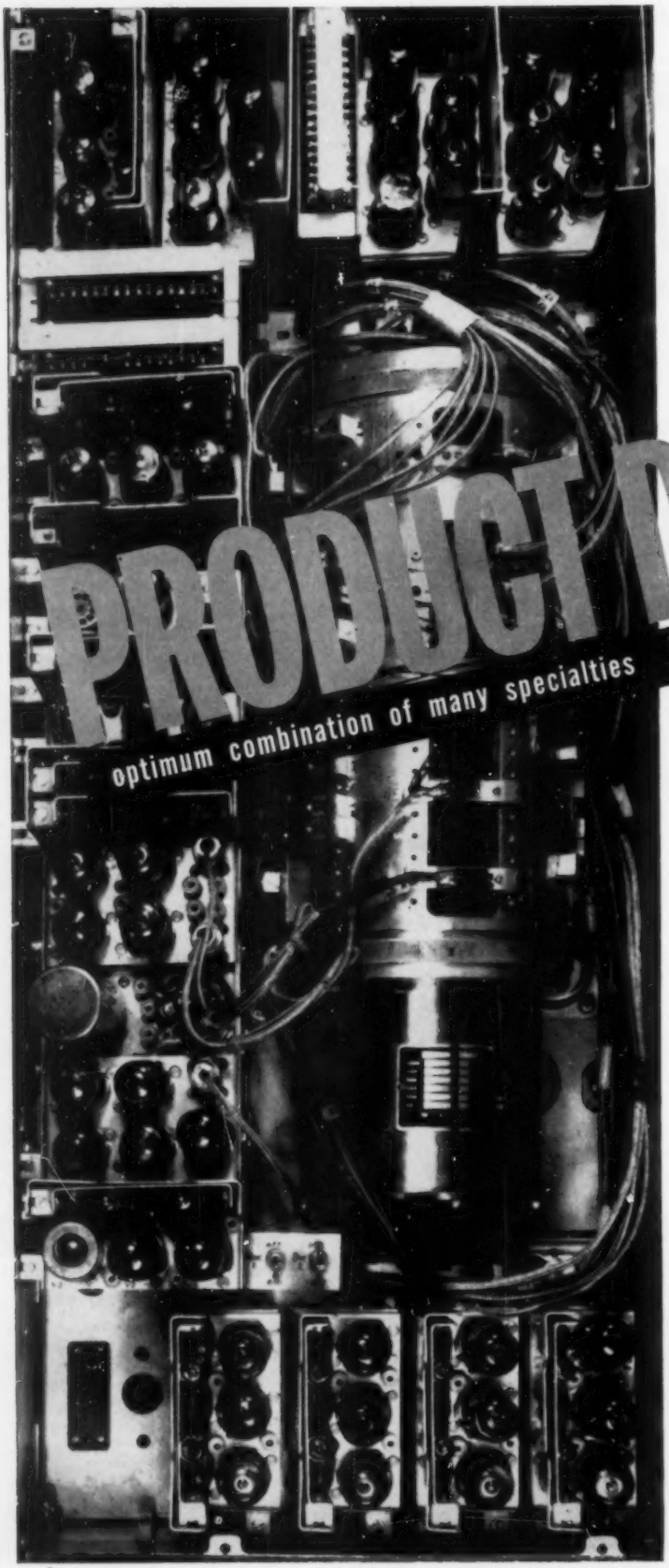

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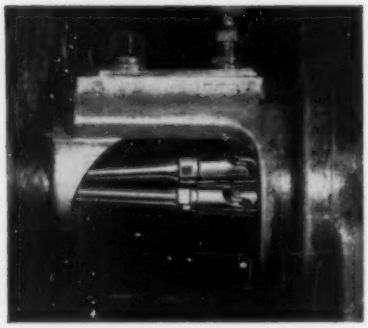
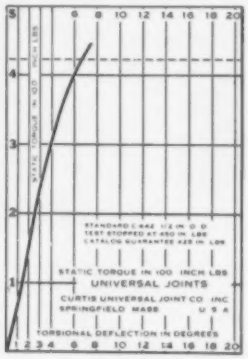
SHELL

Solving a breakage problem AT CLOSE QUARTERS



The manufacturer of this button-drilling machine had a tough problem: the universal joints on these parallel shafts carried such a torque load there were frequent complaints of breakage . . . yet the close centers prohibited use of a larger joint.

THE SOLUTION was a Curtis Universal Joint of the same size.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CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 343.

Magslips–Book, 60 pp. Titled, E-1000, Muirhead Magslips, Applications and Methods of Use. Complete information on magslips and synchros. Comprehensively illustrated throughout by photos, graphs, and circuit diagrams. A brief note on the history of remote indicating devices opens the work, followed by the development of the magslip and the theory of operation.

Among the varied aspects covered are: systems and circuits, remote control and remote indication, the design and layout of new applications, measurements, test and fault location. It concludes with a comprehensive subject index. Published in England. Muirhead Instruments, Inc., 677 Fifth Ave., New York 22, N. Y.

Circle 68, inside back cover

Nickel-Base Alloys–Booklet, 104 pp. Describes chemical composition, physical, mechanical, and high-temperature properties of corrosion-resistant alloys. A table of their comparative resistance to over 250 corrosives is given, as well as laboratory penetration data for some of the common corrosives. Separate section describes techniques for forging, cold working, machining, grinding, and welding. Haynes Stellite Co., Div. of Union Carbide Corp., 420 Lexington Ave., New York 17, N. Y.

Circle 69, inside back cover

Sprayed-on Heating Element–Brochure, 8 pp. Facts and figures on Thermflex radiant heat element that can be sprayed, dipped, or printed on any material or shape where heat is required. Sample is included for testing. Thermflex div., Verrall Moe Electronics, Inc., 1008 Center St., Jefferson, Wis.

Circle 70, inside back cover

Fasteners–Catalog 58, 40 pp. Illustrated guide for selection, specification and purchasing of stock screws, pins, levelers, and adjusting screws. Also, application data on 10 types of nuts applied by resistance welding. Ohio Nut & Bolt Co., 33 First Ave., Berea, Ohio.

Circle 71, inside back cover

Mica Properties–Bulletin, 6 pp. Pocket-size technical bulletin on properties of natural mica, tips on part design. Practical thicknesses to use, tolerances, incorporation of metal inserts. Ford Radio & Mica Corp., 536 63d St., Brooklyn 20, N. Y.

Circle 72, inside back cover

Brass Tube Fittings–Catalog, 48 pp. Lists and illustrates all sizes and types of brass fittings, push-pull controls, assembly instructions on all brass fittings, charts, information, and diagrams on tubing a system, tube fitting, and tools. Completely indexed. Weatherhead Co., Customer Service Dept., 128 W. Washington Blvd., Ft. Wayne, Ind.

Circle 73, inside back cover

Standard Mold Bases–Catalog, 170 pp. Comprehensively illustrated and indexed, spiral-bound catalog of mold bases and moldmakers supplies. 10-p engineering data section and new platen data on plastic, compression and die-casting machines. With prices. Detroit Mold Engineering Co., 6686 E. McNichols Rd., Detroit 12, Mich.

Circle 74, inside back cover

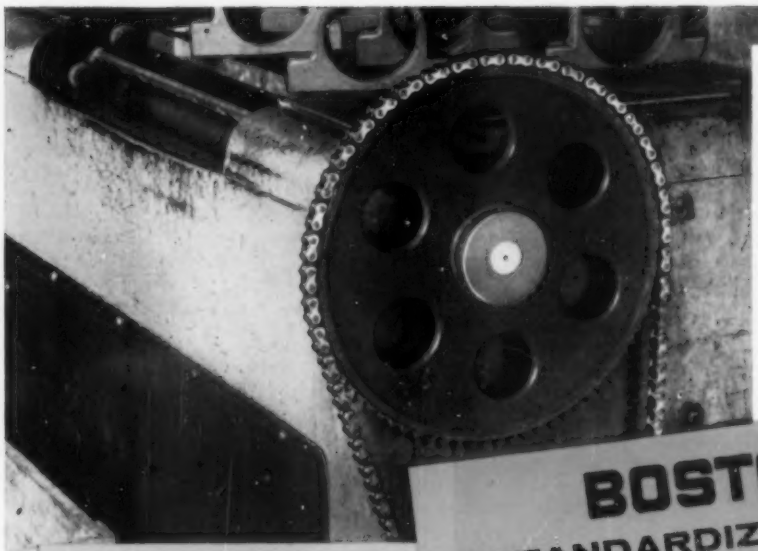
Variable Transformers – Bulletin P257H, 28 pp. Descriptions, ratings, and complete data. Information on 35 types of miniaturized manual and motor-driven variable transformers for high frequency applications. The Superior Electric Co., Dept. 257, 83 Laurel St., Bristol, Conn.

Circle 75, inside back cover

Oil Seals–Catalog 856-C, 68 pp. Lists all stock oil seals, materials available for use as sealing members. A chart indicates the compatibility of each material with a wide range of media.

A complete section on engineering

(Continued on page 292)



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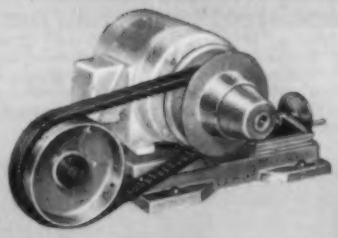
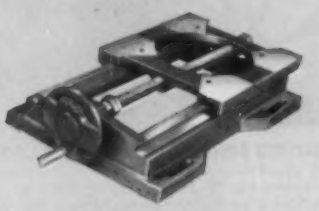


BOSTON VARIABLE SPEED DRIVES

Assembly consists of a self-contained, spring-tension Motor Pulley, a Flat Face Driven Pulley, a heavy duty Belt, and an Adjustable Motor Base. The self-contained design of the Motor Pulley provides a patented safety-lock feature which prevents accidental release of the spring when the disc assembly is removed.

BOSTON VARIABLE SPEED REDUCTOR DRIVES

Consists of above described parts with addition of a BOSTON 100 Series Reductor, — Type U, TW, V, or VW. Illustration (right) shows Variable Speed assembly with Type TW Reductor, used with BOSTON Sprockets and Chain to drive conveyor belt of heat-treating furnace.



ADJUSTABLE MOTOR BASE

A ruggedly proportioned sliding platform, with accurately machined dovetail ways, lead screw, and nut for positive control and vibrationless, noise-free operation. Sold separately, this base is also widely used for many other applications requiring an adjustable motor mounting.

Designed for use with ½ and ¾ HP motors, to provide infinitely variable, 3 to 1 speeds. Speed changes can be made while the drive is running. Output torque ratings remain constant throughout the speed variations. Any driven shaft speed range needed, between 1750 RPM and .5 RPM, can be provided with the use of STANDARDIZED STOCK parts.

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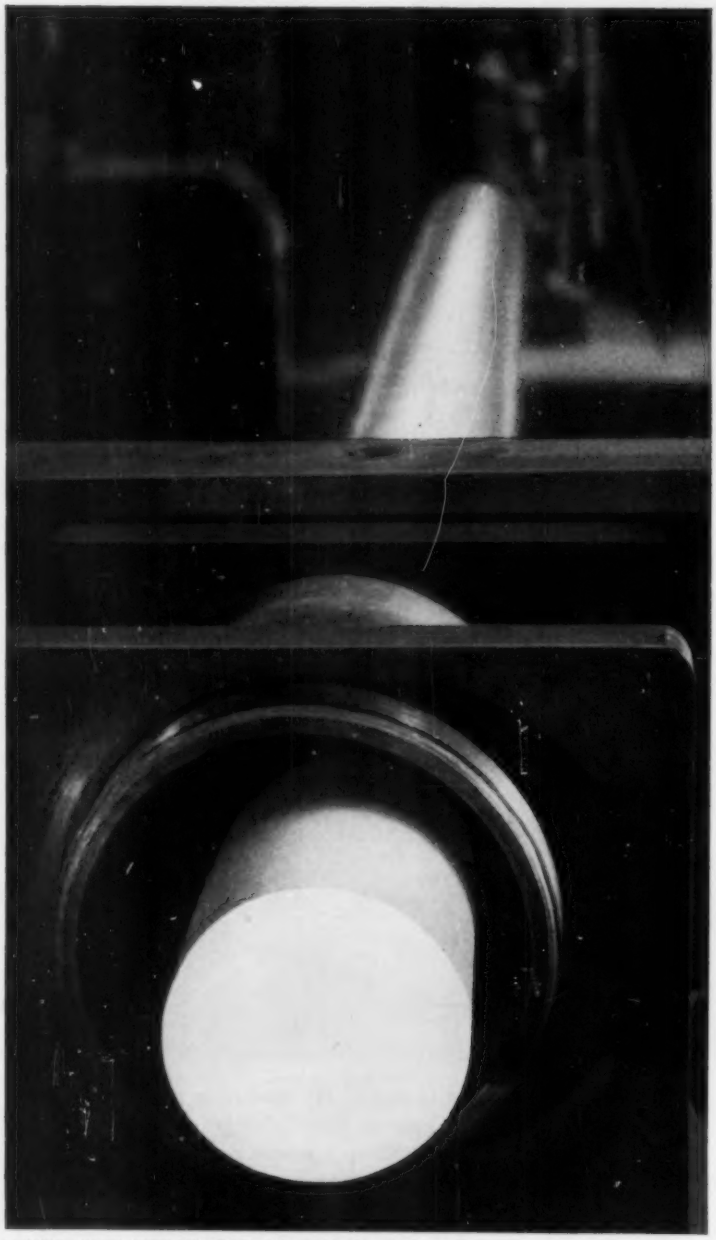
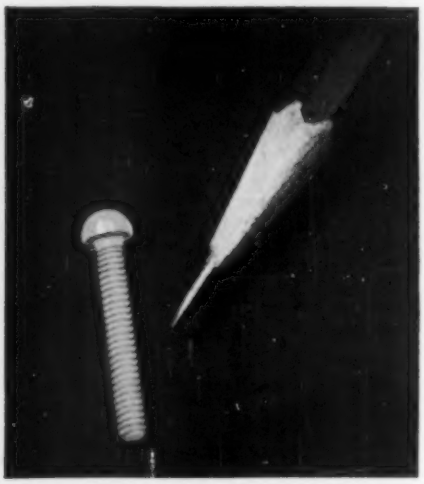


FAMOUS NYLON JOINS NATIONAL'S MATERIALS FAMILY. Proved in thousands of tough applications, versatile Nylon now becomes more useful to the designer than ever. National makes it so in extruded rods and 100% usable finished fabricated parts. Standard rod sizes range from ¼" through 2" in 3 and 6-foot lengths. Inquiries on other sizes and shapes are invited. National's expert engineering counsel assures the commercial soundness and economy of your product. And men, machines and capacity place National in a unique position to serve your immediate needs.

NATIONAL CAN HELP YOU reduce unit product cost or improve product performance at no added cost. Here's why: You can select the "one best material" from over 100 grades of PHENOLITE®, Vulcanized Fibre and NATIONAL Nylon—*without compromise in* properties or cost. You can simplify production and purchasing with the *timed delivery* of 100% usable parts—*from a single reliable source.* You gain competitively with National's new materials and grades —*the direct results of programmed materials-research.*

You benefit by calling National first. Check Sweet's PD File 2b/Na, the Telephone Directory Yellow Pages, or write Wilmington 99, Delaware, Dept. H-8.



MACHINING SKILL GIVES 100% USABLE PARTS as exemplified by this precision-turned 4-40 thread screw of Nylon. National has the skills and equipment to fabricate almost any part you design. Whether your order requires the simplest punching process or the most complex screw machine operation, you get the same result: *100% usable parts.*

INDUSTRY'S BROADEST LINE OF BASIC MATERIALS gives you greatest design freedom. With the addition of Nylon, the National line of materials—already industry's most extensive—grows to more than 100 grades and combinations. These include Vulcanized Fibre and PHENOLITE® Laminated Plastic. The result is greater selectivity for you—unbiased recommendations from National—and virtually any combination of properties you desire.

NATIONAL
VULCANIZED FIBRE CO.
WILMINGTON 99, DELAWARE

In Canada:
NATIONAL FIBRE COMPANY OF CANADA, LTD., Toronto 3, Ontario

FORGED STEEL FOR SURPLUS STRENGTH

NOELTING

Faultless CASTER

H 1600 HEAVY DUTY

EXCLUSIVE HORN CONSTRUCTION RESISTS SHOCKS, PROTECTS LOADS

For safe movement of tremendous loads on casters capable of resisting high impact shocks, yet swivel and roll with minimum effort, Faultless presents a materials-handling man's answer in the H1600 Forged Steel Caster.

Faultless design engineers drew on a background of more than fifty years experience with caster problems when they perfected an exclusive heavy duty horn design pronounced the most durable forged steel construction ever offered in a caster.

The cutaway illustration shows the large diameter raceway and large ball bearings that carry the load around machined hardened surfaces. A Timken combined radial and thrust bearing is nested in the horn top plate. Timken tapered roller bearings are also furnished in the Forged Steel and Semi-steel wheels.

If your movements of excessively heavy loads are encountering high impact shocks, your problem will be solved with this new H1600 Series Forged Steel Caster. Your nearby Faultless Industrial Distributor maintains a substantial inventory of Faultless Casters for immediate delivery. Call him today about this new H1600 Series Caster.

Exclusive with Faultless

For the most durable construction possible to make Faultless engineers machined the heavy drop forged horn top plate to form strong shoulders against which the heavy steel side members or legs are securely welded. The load strains are thus transferred from the welding bead to the top plate — the most durable forged steel construction made.

H 1600 SERIES HEAVY DUTY CASTER SHOWN WITH FORGED STEEL WHEEL

DESIGN FEATURES

1. HEAVY DROP FORGED CASTER TOP PLATE machined for load bearing balls.

2. HEAVY DROP FORGED HORN TOP PLATE machined for load and thrust bearing raceways.

3. SWIVEL HEAD consists of a complete row of hardened ball bearings operating in lubricated machined raceway and Timken combined radial and thrust bearing. Raceways case-hardened.

4. CASTER HORN LEGS made of heavy steel, deeply embossed and formed for additional strength. The embossing forms a shoulder to prevent axle from turning. NOTE: The forged top plate of the horn is machined to form a perfect shoulder against which the side members or legs of the horn are securely welded, thus transferring the strains from the welding bead to the top plate—the most durable forged steel construction made —an exclusive FAULTLESS feature.

5. ADJUSTABLE KING BOLT 1" in diameter, assembled with lock-nut and securely staked.

6. AXLE BOLT 1" in diameter. Bolt head held against horn embossing shoulder to prevent axle turning. Heavy duty lock nut is standard.

7. WHEEL—Forged steel wheel supplied in 6" size. Semi-steel wheel supplied in 8" size. Vulcanized rubber tread wheel supplied in 6" and 8" sizes. Roller bearing standard in all wheels. Timken tapered bearings can also be supplied in forged and semi-steel wheels.

8. GREASE FITTINGS easily accessible for fast, thorough lubrication of swivel head and wheel.

9. FINISH—lustre green lacquer.

FAULTLESS CASTER CORPORATION, EVANSVILLE 7, INDIANA

Offices in Atlanta, Baltimore, Boston, Buffalo, Chicago, Cleveland, Dallas, Detroit, Grand Rapids, High Point, Indianapolis, Los Angeles, New Orleans, New York, Philadelphia, Portland, Seattle, St. Louis, Canada: Stratford, Ontario

"POP"® RIVETS PULL PARTS TOGETHER...

Flat sheets that must be pulled to a contour and fastened from one side no longer pose a fastening problem with "POP" Rivets.

Greater design flexibility with "POP" Rivets. An air-operated pulling tool weighing only 1 lb. 14 oz. sets up to 1200 per hour with unskilled labor.

For parts that must be pulled together and fastened from one side, you can't beat the high clinching action of "POP" Rivets. Particularly effective for riveting curved panels, moldings, and trim — as well as for many mechanical and electrical assemblies.

"POP" Rivets are a new concept in fastening convenience. They are inserted in the hole and a pulling tool draws the setting mandrel through the rivet until the mandrel breaks under tension. This gives you a tight, positive, vibration-proof grip over a wide range of stock variations. A complete line of portable pulling tools to meet the most difficult types of installations in factory or field is available.

Investigate the many advantages of "POP" Rivets. Remember, "POP" Rivets can probably save you money on *assembly costs* even if your present fasteners are FREE. Write or call us today for further information or plant demonstration by one of our application engineers.

"POP" RIVET DIVISION

UNITED SHOE MACHINERY CORPORATION

West Medway, Mass., KEystone 3-6611

data covering shaft material, finish, hardness, shaft size and tolerance, shaft speeds, eccentricity, pressure, and lubrication. Included are installation procedure and diagrams. Also, a section on preventive maintenance. Chicago Rawhide Mfg. Co., 1301 Elston Ave., Chicago 22, Ill.

Circle 76, inside back cover

Leaded Alloy Steel–Brochure, 4 pp. Covers general information, analysis and mechanical properties of Elastuf PB. Includes selector chart for machinery steel. Horace T. Potts Co., Erie Ave. and D St., Philadelphia 34, Pa.

Circle 77, inside back cover

Diaphragm Operated Valves–Bulletin, 4 pp. Information on design, construction, maintenance, operating pressures. Tables indicate dimensions and pressure data. Illustrated. Seely Instrument Co., Inc., Subsidiary of Aeronautical Mfg. Corp., Niagara Falls, N. Y.

Circle 78, inside back cover

Breadboard Parts–Catalog 575, 24 pp. Complete descriptions, indexed and comprehensively illustrated in two colors, of all parts necessary for the assembly of gear trains and servomechanisms. Helipot Technical Information Service, Newport Beach, Calif.

Circle 79, inside back cover

Electrical Insulation–Catalog 21, 12 pp. Has illustrated descriptions of electrical insulation materials, with prices and ordering data. Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6, Ill.

Circle 80, inside back cover

Relays–Catalog 157, 16 pp. Describes printed circuit relays, miniature and subminiature, 6PDT and power relays, snap action relays, 400 cps relays, rectifier relays. Also, relays with hermetically sealed, dust-tight enclosures. Magnetcraft Electric Co., 3350Y W. Grand Ave., Chicago 51, Ill.

Circle 81, inside back cover

Self-Locking Pins–Brochure, ADI 1268-257, 6 pp. Illustrates and gives complete information on materials, finishes, head styles, dimensions, and load facts of the line of 5440 single-

(Continued on page 296)

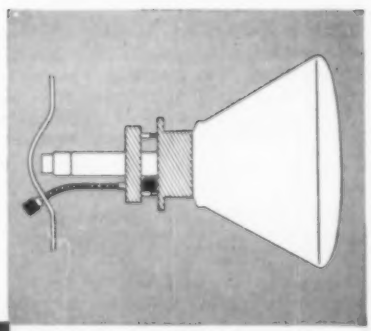
S.S.White

Flexible Shafts Make Operations Easier!

The manufacturer of this hue control for a color TV set uses a standard S.S. WHITE FLEXIBLE SHAFT to cope with a 90° turn. The shaft needs no alignment . . . can be quickly and easily installed. Costs are lower . . . manufacturing is simpler . . . assembly operations are easier, faster.

You can often reduce a complex system of gearing, universals and other parts to ONE FLEXIBLE SHAFT! Flexible shafts also make better designs possible . . . allowing new freedom in locating connected members to save space and facilitate operation and servicing.

For many years, these versatile shafts have been making industrial operations easier. They are tough and rugged . . . yet have the sensitivity you need for delicate adjustments. Design engineers and manufacturers discover new uses for S.S. WHITE FLEXIBLE SHAFTS every day. Can your product be improved by a simple . . . better . . . less costly way of transmitting power or remote control? Our engineers will be glad to work out a flexible shaft application with you. Just write to

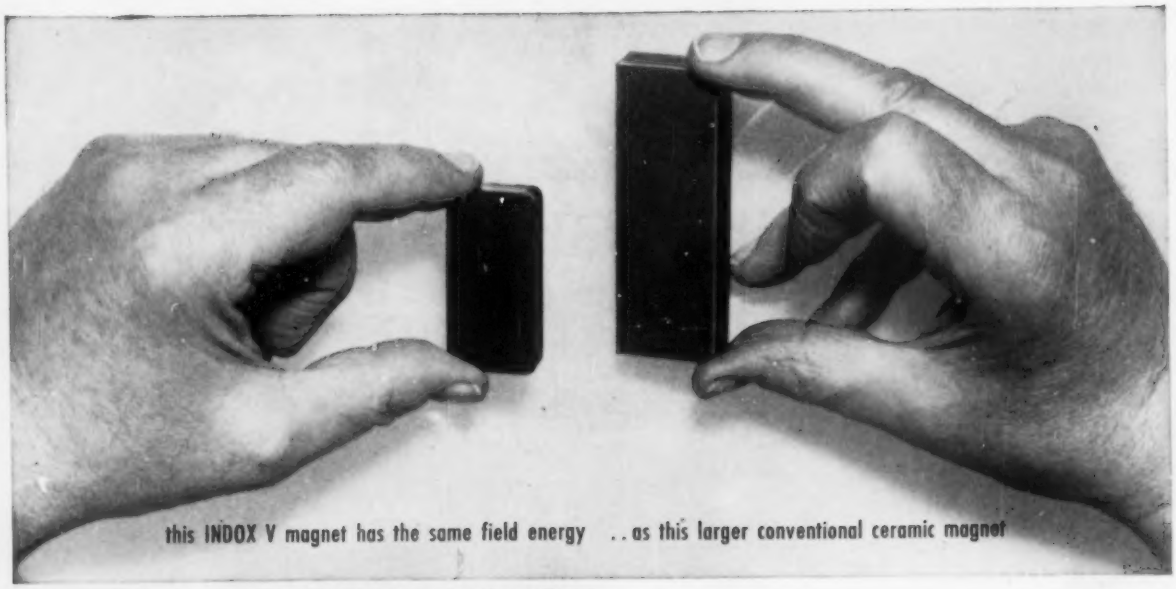


S.S.White

FIRST NAME IN FLEXIBLE SHAFTS

USEFUL DATA on how to select and apply flexible shafts. Write for Bulletin 5601.

S. S. White Industrial Division, Dept. J, 10 East 40th St., New York 16, N. Y. Western Office: 1839 West Pico Blvd., Los Angeles 6, Calif.



350% STRONGER . . .

NEW Indox V ceramic magnet!

Indox V . . . another first from the research and development laboratories of The Indiana Steel Products Company . . . produces 3½ times greater energy than conventional ceramic magnets of the same weight or same size. This unique new permanent magnet material is now available. It offers these important advantages:

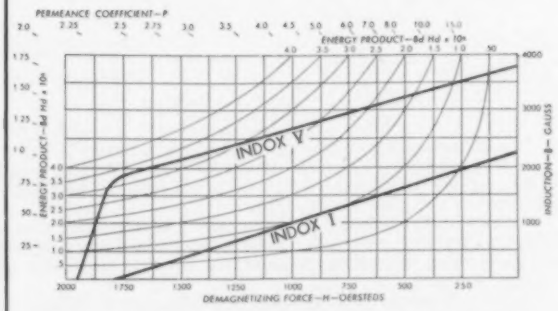
Indox V requires no critical materials. It is a highly oriented barium ferrite . . using inexpensive, noncritical, raw materials that are constantly available. Shortages in times of emergency cannot occur.

Indox V requires less space, weight to do same job. Volume and weight comparisons show that the energy of Indox V far exceeds Indox I . . and is comparable to Alnico V, the strongest permanent magnet material commercially available.

Indox V offers high resistance to demagnetization. Indox V magnets can be designed for applications where extremely high demagnetizing forces exist . . without irreversible losses occuring. This means it can be used where other types of magnets have been impractical . . for example, in stators of medium-size electric motors where electromagnets are now being used.

. . ideal for:

- D-C motors
- Synchronous drives
- Traveling wave tubes
- High-fidelity loud-speakers
- Eddy current drives
- Tractive devices where size is important



Comparison of demagnetization and energy product curve for conventional Indox I ceramic magnets and the new, high energy Indox V magnets.

JUST PUBLISHED! *This two-page data sheet gives detailed information on new high energy Indox V. Use this coupon to request your copy. Ask for Bulletin 16-C8.*

THE INDIANA STEEL PRODUCTS COMPANY • VALPARAISO, INDIANA

. . the world's largest manufacturer of permanent magnets

Name_____

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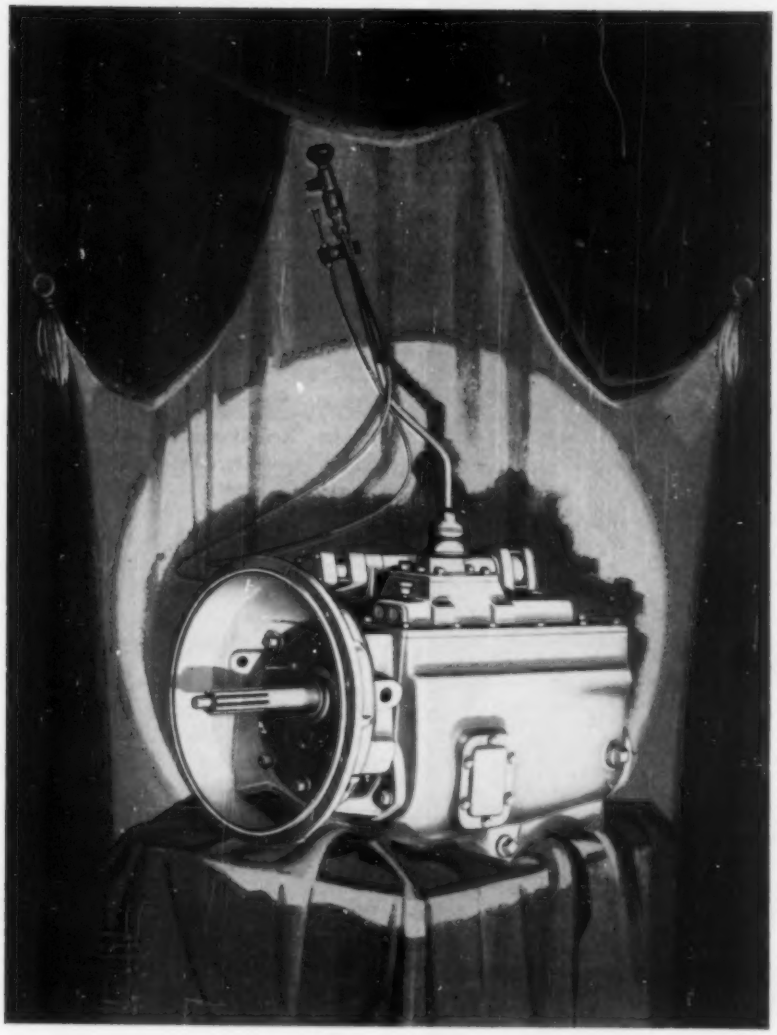
16-C8.

INDIANA PERMANENT MAGNETS

In Canada: The Indiana Steel Products Company of Canada Limited • Kitchener, Ontario

The New Spicer SYNCHRO-MASTER TWELVE

— newest achievement in Dana Creative Engineering



This is a new concept of excellence in mechanical engineering design and manufacture.

This is a new concept of efficiency in power transmission for heavy-duty vehicles.

This is the revolutionary new Spicer Synchro-Master 12-Speed Transmission:

12" shorter, 200 pounds lighter than any other multiple-speed transmission of comparable capacity; and with sufficient low gear reduction and spread to handle various road conditions without need for auxiliary transmission or two-speed axle!

Spicer Synchro-Master Features

Blocker-type sychronizers in all speeds, forward and reverse.
All six low range ratios available in reverse. Forced feed lubrication.
Screen for filtering oil.
Standard six-bolt S.A.E. power take-off apertures on each side.
Equally spaced steps between ratios.
Replaceable bearing retainer inserts in all case bores.
Tower or remote control types.

Ask Dana engineers to help you adapt this revolutionary new Spicer Transmission to your heavy-duty truck requirements, for new standards of economy and performance.

DANA PRODUCTS Serve Many Fields

AUTOMOTIVE: Transmissions, Universal Joints, Propeller Shafts, Axles, Powr-Lok Differentials, Torque Converters, Gear Boxes, Power Take-Offs, Power Take-Off Joints, Clutches, Frames, Forgings, Stampings.

INDUSTRIAL VEHICLES AND EQUIPMENT: Transmissions, Universal Joints, Propeller Shafts, Axles, Gear Boxes, Clutches, Forgings, Stampings.

AVIATION: Universal Joints, Propeller Shafts, Axles, Forgings, Gears, Stampings.

RAILROAD: Transmissions, Universal Joints, Propeller Shafts, Generator Drives, Rail Car Drives, Pressed Steel Parts, Traction Motor Drives.

AGRICULTURE: Universal Joints, Propeller Shafts, Axles, Power Take-Offs, Power Take-Off Joints, Clutches, Forgings, Stampings.

MARINE: Universal Joints, Propeller Shafts, Gear Boxes.

Many of these products manufactured in Canada by Hayes Steel Products Ltd., Merritton, Ontario

DANA CORPORATION • Toledo 1, Ohio

DANA Spicer

precision
Fluorocarbon Parts
meet exacting specifications
...cut assembly costs
Profit from precision parts, fabricated from TEFLON*, KEL-F†, and other plastics—by United States Gasket Company.
Quality controlled "from powder to part," they assure uniform electrical, chemical and physical characteristics of the highest quality. Uniform density and dimensional stability permit superior accuracy and dependability in the finished part.
Come to USG for all your requirements — Fluorocarbon sheet, tape, tubing, cylinders, rods, bars—as well as molded and machined parts to your own specifications. Write for Bulletin No. IN-554.
*duPont Trademark †M. M. & M. Trademark
UNITED STATES GASKET COMPANY
Camden 1, New Jersey
United States Gasket
Plastics Division
OF THE GARLOCK PACKING COMPANY

acting, self-locking, quick-release pins. Diagrams for callout procedures. Aviation Developments, Inc., P. O. Box 391, Burbank, Calif.

Circle 82, inside back cover

Valves—Bulletin No. 357, 4 pp. Complete specifications of the relief and back pressure valve line. Dimensions and materials are also included. Milton Roy Co., 1300 E. Mermaid Lane, Philadelphia 18, Pa.

Circle 83, inside back cover

Pumps and Valves—Catalog 800, 12 pp. Titled, Positive Flow Control, proportioning pumps and diaphragm valves are described in detail. Materials, capacities, and pressures are shown for each. Also a diaphragm selection chart. Hills-McCanna Co., 3025 N. Western Ave., Chicago 18, Ill.

Circle 84, inside back cover

Plastic Reinforcement—Sales folder, 8pp. Two-color, illustrated brochure on Garan woven roving, produced from parallel glass fibers. Describes the new material and its applications. Includes specifications chart. L.O.F. Glass Fibers Co., 1810 Madison Ave., Toledo, Ohio.

Circle 85, inside back cover

Investment Cast Vacuum Alloys—Booklet, 7pp. Technical data on the economics of vacuum melting, the equipment it needs, cost, and selling price. With charts and diagrams. Cannon-Muskegon Corp., 2875 Lincoln St., Muskegon, Mich.

Circle 86, inside back cover

Piezoelectric Pressure Transducers—Technical Note No. 2, 2 pp. Performance data. Characteristics discussed include: linearity, dynamic range, and effects of aging, high static pressure and temperature. Atlantic Research Corp., Alexandria, Va.

Circle 87, inside back cover

Cabinets—Catalog, 26 pp. Illustrates and describes cabinetry for use with automation, electronic equipment. Metal Products Div., Mid-West Conveyor Co., 7th and Sunshine Rd., Kansas City, Kans.

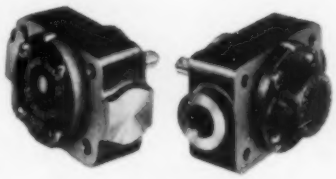
Circle 88, inside back cover

Printed Circuits—Tech-Lit, Vol. 1, No. 5, 6 pp. Includes a 2 pp. article

(Continued on page 300)

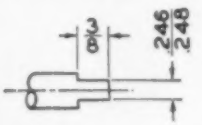
NOW! Have Reliable Lubrication at Minimum Cost

Models LF and RF
Capacities 55-170 g.p.h. at 1800 r.p.m.
Designed for flange mounting without shaft seal; with *choice* of internal or external porting. Model RF has automatic reversing feature which permits driving the pump in either direction...without changing direction of flow or port positions.

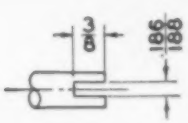


Models LFD and RFD
Capacities 60-180 g.p.h. at 1800 r.p.m.
Designed for non-directional service; for flange mounting with internal porting. Variations for external porting and/or shaft seal are shown below. Model RFD has the automatic reversing feature which permits driving the pump in either direction...without changing direction of flow or port positions.

ALTERNATE SHAFT DRIVE ENDS
For All Models



MODIFICATION "A"



MODIFICATION "B"

Tuthill "Cartridge-Type" Pumps Solve This Problem for Plant Maintenance...and Original Equipment Manufacturing

Durable—Reliable—and Available from Stock!

1. The demand for minimum cost lubrication pumps without sacrifice in performance, durability and reliability is *ideally* satisfied by the TUTHILL series of Models LF, RF, LFD and RFD *cartridge-type* pumps.

2. TUTHILL "cartridge" pumps get their reputation as cost-savers from their special design for original equipment use, their durable construction, their reliability...and the fact that they are *available from stock*. Note their compact size as shown in the photos above. Consider how all waste space has been eliminated for more adaptability. Think how they can be easily applied to your *own* requirements...in your plant...or in your equipment manufacturing plans.

3. These variables are available:

a. Pumps with...*or without*...automatic reversing performance

b. Pumps with...*or without*...a shaft seal

c. Pumps with internal...*or external*...porting

d. Pumps with *variations* of both internal and external porting

4. TUTHILL Catalog Section 108 contains line drawings showing each model in detail, shaft rotation and porting arrangements and other vital statistics to help you select the RIGHT model. Fill out the attached coupon—or write.

TUTHILL PUMP COMPANY
963 E. 95th Street, Chicago 19, Illinois

Gentlemen:

☐ Please send me Catalog Section #108
☐ Please send the complete catalog on the Tuthill line
☐ Have your representative call

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

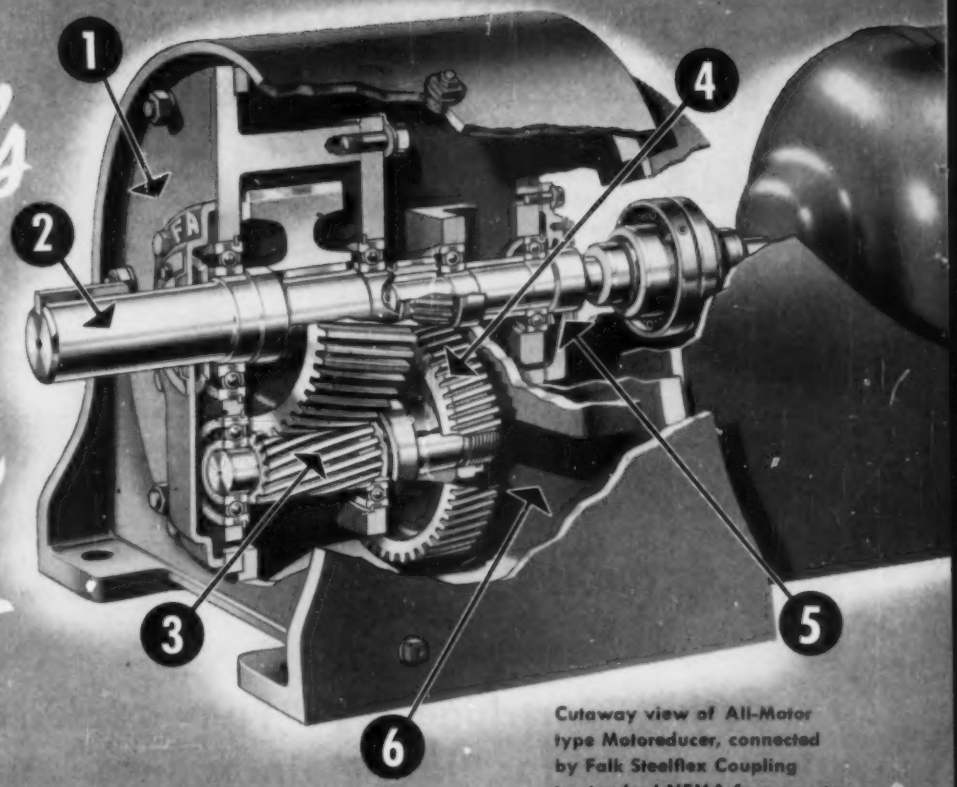
Tuthill Manufactures a Complete Line of Positive Displacement Rotary Pumps in Capacities from 1 to 200 GPM, for Pressures to 600 PSI, Speeds to 3600 RPM.

TUTHILL PUMP COMPANY

963 East 95th Street, Chicago 19, Illinois
Canadian Affiliate:
Ingersoll Machine & Tool Company, Ltd., Ingersoll, Ontario, Canada

PUMPS FOR YOUR PURPOSE

Here's the inside story—



Cutaway view of All-Motor type Motoreducer, connected by Falk Steelflex Coupling to standard NEMA frame motor

WHY Falk Motoreducers give better service—have longer life

Here is the "inside story" behind the all-steel All-Motor type FALK Motoreducer's universal reputation as a gear drive unmatched in quality, efficiency, dependability, ease of maintenance and long life. These "In-built" factors are—

1 **ALL-STEEL HOUSINGS.** Rugged, strong, rigid...all parts are manufactured from heavy steel plate, formed and welded in the Falk Weld Shop.

2 **LARGE OVERHUNG LOAD CAPACITY.** Large shafts, oversize bearings...rigid mountings with wide bearing spans to handle maximum applied loads.

3 **PRECISION GEARING.** Heat-treated alloy steel gearing, precision cut and shaved after heat treatment to eliminate distortion. Quiet, crown-shaved pinions.

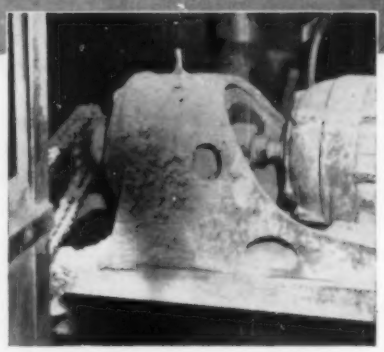
4 **EXTRA-CAPACITY GEARING.** Special extra-capacity gear-tooth form with larger contact area gives greater strength, higher load-carrying capacity.

5 **SEALED HOUSINGS.** Splashproof, dustproof, oil-tight construction. Dual closures and one-way vents keep oil in, dust and moisture out.

6 **POSITIVE LUBRICATION.** Large sump capacity...oiltight construction assures clean lubricant...revolving elements lubricated by direct dip.

When you buy or specify the All-Motor type FALK Motoreducer, you get all these—plus the tremendous advantage of full interchangeability of motors. Switch motors as desired—use any make, style or type of standard foot-mounted motor within the unit's AGMA rating—with a minimum of difficulty or "down time."

Available in sizes up to 75 hp—*with or without motor*—from convenient factory, field or distributor stocks, from coast to coast. **Write for Bulletin 3100.**



60,000 HOURS WITHOUT A FAILURE!

Sixty thousand hours is a lot of hours—but the FALK Motoreducer in the unretouched photo above has served that long without failure or need of repair.

This 3 hp unit is one of over 60 FALK Motoreducers in daily service in an Eastern plant of a large milling company, whose president says, in part:

"One of the main advantages of FALK Motoreducers is their adaptability to any motor. Reducers and motors can be easily interchanged....Our service records confirm the wisdom of our choice of FALK equipment as our standard."

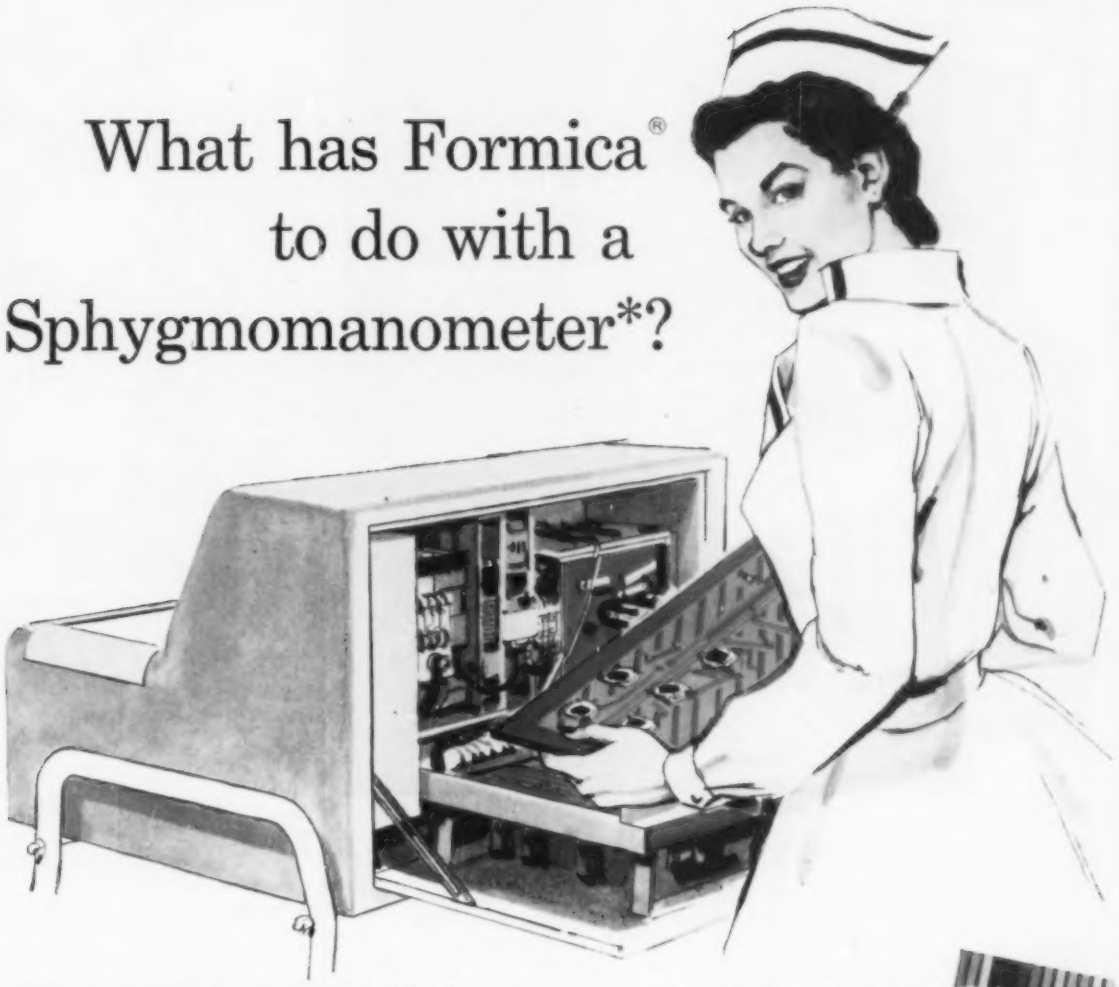
FALK ...a good name in industry

THE FALK CORPORATION, MILWAUKEE, WISCONSIN

MANUFACTURERS OF

- Motoreducers
- Speed Reducers
- Flexible Couplings
- Shaft Mounted Drives
- High Speed Drives
- Special Gear Drives
- Single Helical Gears
- Herringbone Gears
- Marine Drives
- Steel Castings
- Weldments
- Contract Machining

What has Formica® to do with a Sphygmomanometer*?



This sphygmomanometer* – or automatic blood pressure recorder, if you prefer – demonstrates how Formica XXXP-36 copper clad laminated plastics is being used in a versatile printed circuit application.

In this case, a printed circuit provides the absolute interchangeability of parts in the field which simplifies and reduces the cost of field service on complicated electronic products.

The application versatility of Formica XXXP-36 then can be applied to many different kinds of electrical and electronic applications. You'll benefit especially from Formica-4 – the complete laminated plastics service that cuts engineering time, reduces component parts costs and assures delivery schedules for mass production operation.

FORMICA 4

CYANAMID

FI-1543

(1) Application Engineering
(2) Research
(3) Fabricating
(4) Customer stock service

Complete information on how Formica Laminated Plastics serves product designers in every field is contained in this 20-page Technical Catalog. Send for your free copy.

Formica Corporation
4516-7 Spring Grove Ave. Cincinnati 32, Ohio

Please send me a free copy of Formica Technical Catalog form 627.

Name_____

Company_____

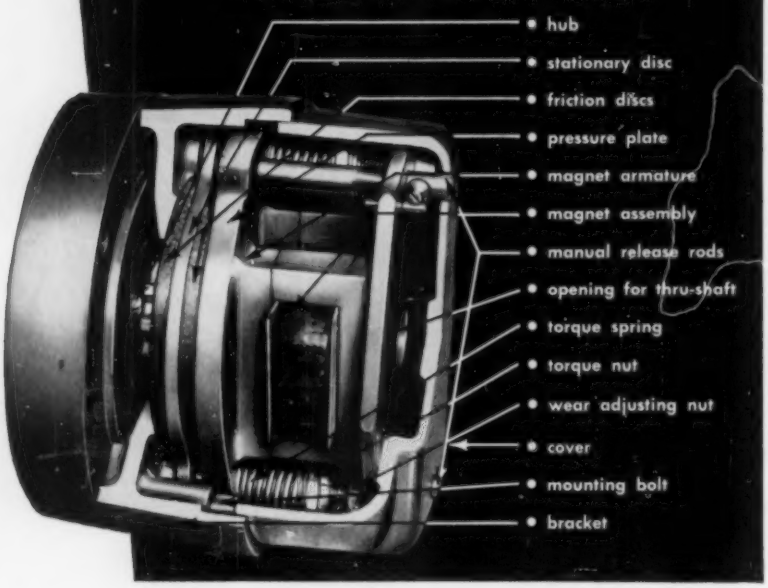
Title_____

Address_____

City_____ Zone_____ State_____

COMPARISON PROVES

DINGS *direct-acting*
MAGNETIC DISC BRAKES
are your best buy!



COMPARE these outstanding advantages

- Direct-acting for positive, instantaneous stops
- Thru-Shaft design to solve installation problems
- Accommodate standard NEMA shaft extensions
- Designed for mounting on all old and new re-rated NEMA type "C" motor flanges
- Wide torque range—1½ to 175 lbs. ft.—easy torque adjustment
- Fail-safe design in event of power failure
- Simple design and rugged, compact construction

COMPARE for operating and maintenance economy

- No mechanical linkages or levers to maintain
- No solenoids required
- No need for auxiliary fuses, rectifiers, rheostats, auxiliary relays or extra wiring

NEW DINGS EXPLOSION-PROOF MAGNETIC DISC BRAKES
UL approved for hazardous locations

Now Dings combines all the advantages of direct-acting magnetic disc brakes with explosion-proof features tested and approved by Underwriters Laboratories . . . the "707" Series for Class I, Group D hazardous locations, and the "709" Series for Class I, Group C and D and Class II, Groups E, F, G.

Always specify Dings Brakes from your regular motor supplier, or ask about Dings complete engineering service for your brake problems.

DB157½

DINGS BRAKES, INC.
A Subsidiary of Dings Magnetic Separator Co.
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on Working with Printed Circuits. Westinghouse Electric Corp., Metuchen, N. J.

Circle 89, inside back cover

Cycling Drive Unit–Brochure, 12 pp. Tells what the motion-controlling drive unit is, how it is used, basic arrangements, mounting options, and assemblies, with charts and diagrams. Cycledynamics, Inc., 19025 W. Davison, Detroit 23, Mich.

Circle 90, inside back cover

Variable Speed Drives–Bulletin 1640-BIP 8 pp. Includes four pages of tables on belts applicable to various manufacturers' belt part numbers to facilitate reordering, complete listing of V-belt sizes, and an interchange list of the firm's belts that correspond with other manufacturers' belts. Worthington Corp., Harrison, N. J.

Circle 91, inside back cover

Steel Tubing and Pipe–Data Chart. Sec. B, No. 1. Fully explains tolerances for steel tubing and pipe. Printed on heavy stock to be filed, tacked on the wall, or slipped under glass for ready reference. Peter A. Frasse & Co., Inc., 17 Grand St., New York 13, N. Y.

Circle 92, inside back cover

Chains, Sprockets, Buckets–Bulletin 5766, 24 pp. Has selection tables for chains and buckets; also, guides to bucket spacing, head-shaft wheel dia and rpm, foot-shaft sprocket and size, and casing size, as well as comprehensive drive-selection data. The complete line is illustrated. Chain Belt Co., Milwaukee 1, Wis.

Circle 93, inside back cover

Variable Speed Drives–Catalog, 8 pp. Features five drive tables giving a wide selection of speed ratios, drive-speed ranges and center distances for motors up through 20 hp. Describes patented single-groove, variable-flange sheaves. Dayton Rubber Co., Dayton, Ohio.

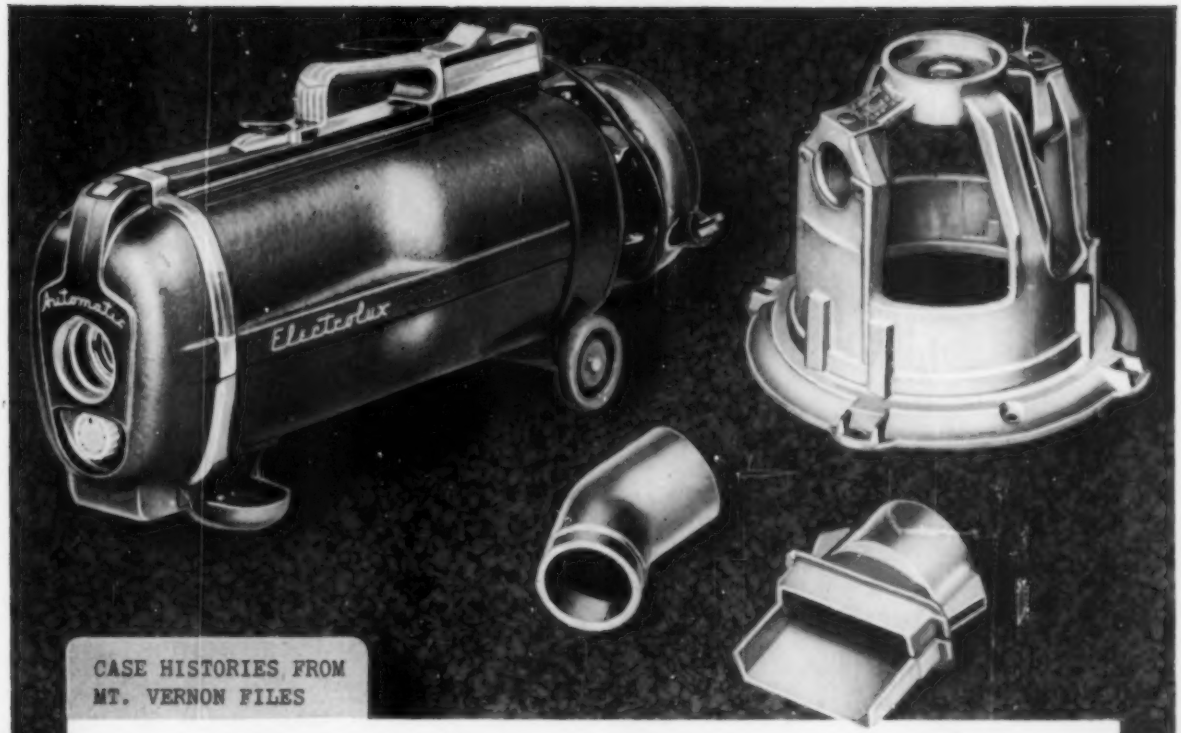
Circle 94, inside back cover

Electrical Connectors–Booklet, 8 pp. Describes connectors, terminals, splices and panels. Burndy Corp., Norwalk, Conn.

Circle 95, inside back cover

Air Conditioner Thermostat–Bulletin RT-802, 4 pp. Describes new

(Continued on page 304)



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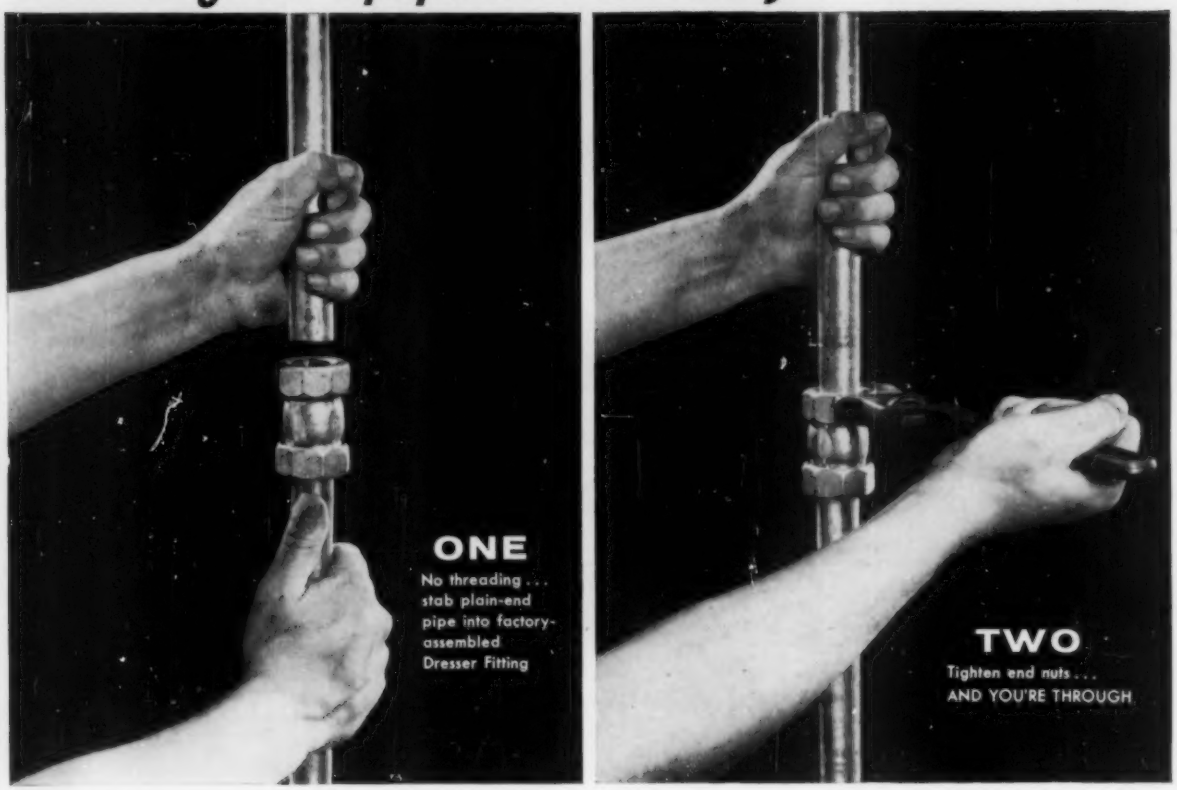
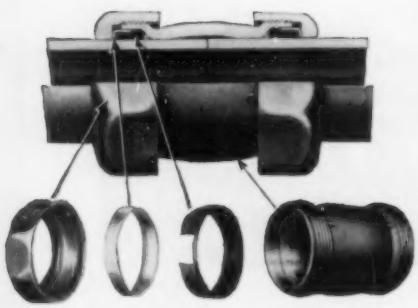


Dresser "30-second" compression fittings speed pipe joining!



Production line assembly of equipment involving piping can be speeded up immeasurably with Dresser Fittings because . . .

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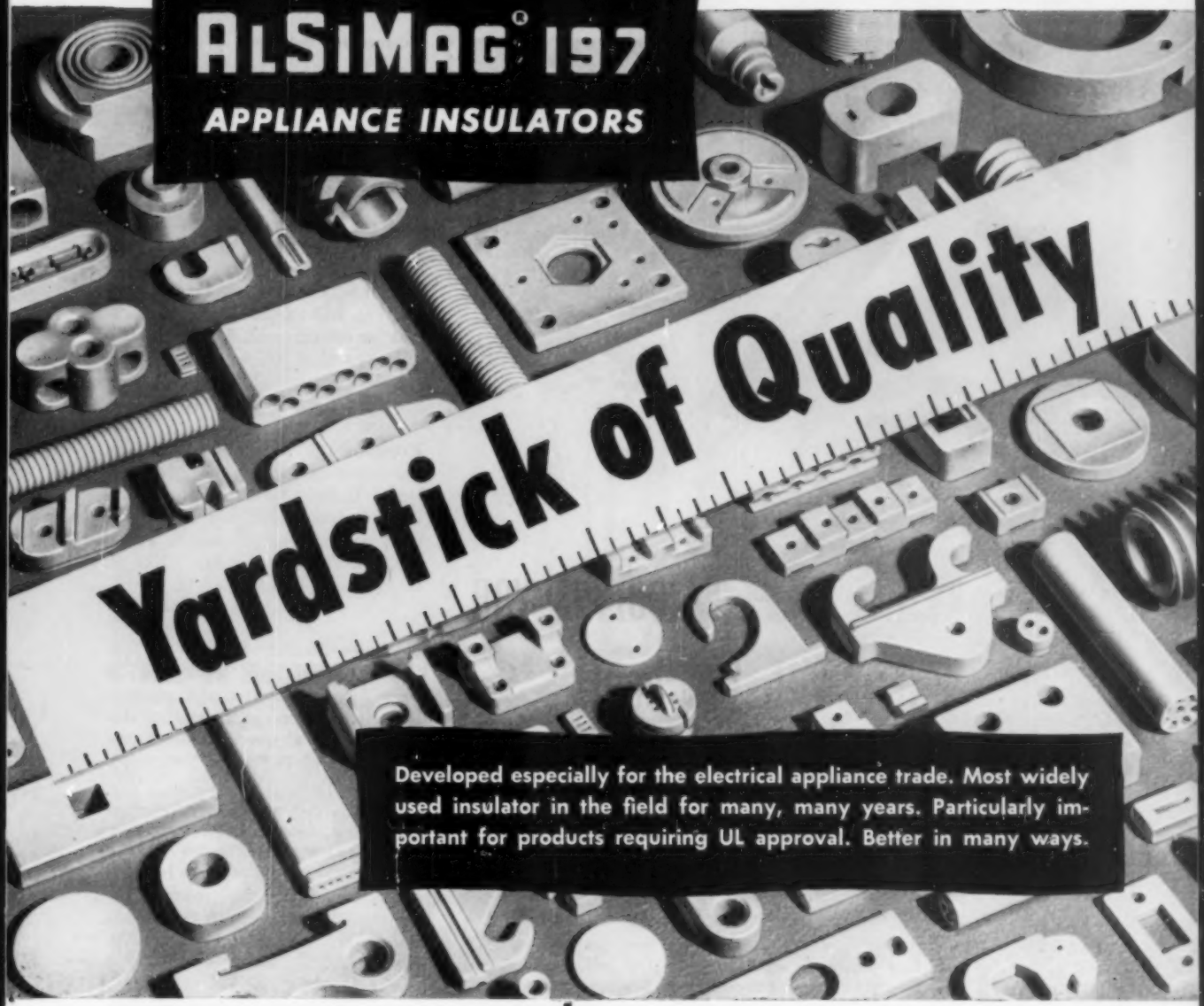

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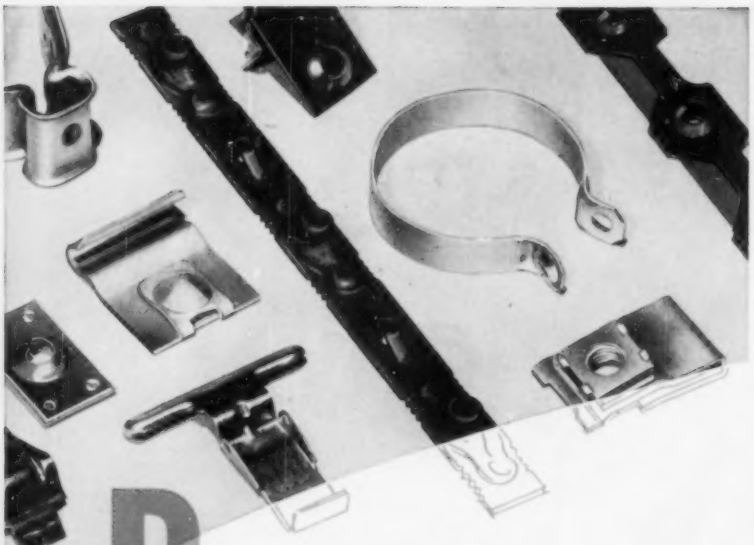

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thermostat with detailed cut-away drawing and installation data. Robertshaw-Fulton Controls Co., 110 E. Otterman St., Greensburg, Pa.
Circle 96, inside back cover

Motor Generator–Data Sheet 869, 2 pp. Illustrated, with complete specifications, electrical characteristics, torque-speed curve, two-view drawing, and schematic of the Beckman servomotor-rate generator. Helipot Technical Information Service, Newport Beach, Calif.
Circle 97, inside back cover

Extrusion Data–Brochure, 12 pp. On the extrusion process and its advantages. Includes mechanical specifications, recommended uses, and reference numbers for aluminum alloys. Precision Extrusions, Inc., 720 E. Green Ave., Bensenville, Ill.
Circle 98, inside back cover

C Cores–Booklet B-7048, 24 pp. Covers design and application of cores for transformers and reactors. Illustrated with photographs, diagrams, data charts. Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30, Pa.
Circle 99, inside back cover

Motors, Drives–Bulletin A-2501, 8 pp. *The Moving Force of Industry* describes in photos and captions the complete line of a-c and d-c motors and drives. Reliance Electric and Engineering Co., 24701 Euclid Ave., Cleveland 17, Ohio.
Circle 100, inside back cover

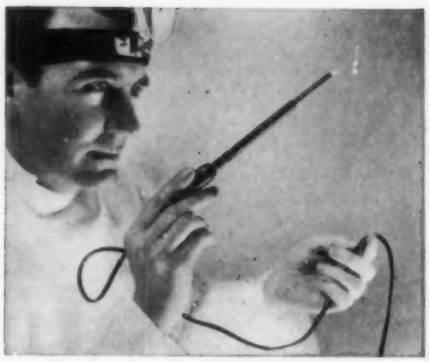
Relief and Back-Pressure Valve–Catalog Sheet, 1 p. Describes a dual-purpose valve for condensing and non-condensing systems. Includes cut-away diagram, design features, valve dimensions. Atlas Valve Co., 280 South St., Newark 5, N. J.
Circle 101, inside back cover

Proving Rings–Brochure, 12 pp. A primer, *The A-B-C's of Accuracy in Weighing and Force Measurement Systems*, explains proving rings and their use. Morehouse Machine Co., 233 W. Market St., York, Pa.
Circle 102, inside back cover

Valves, Driers, Strainers–Catalog 102, 16 pp. Provides illustrated descriptions of valves and other parts for re-
(Continued on page 306)

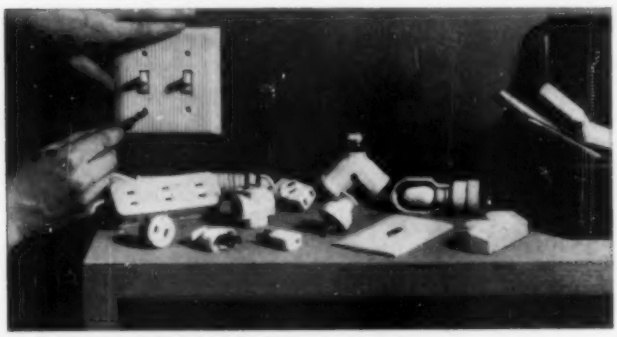
CYANAMID

PLASTICS NEWSFRONT



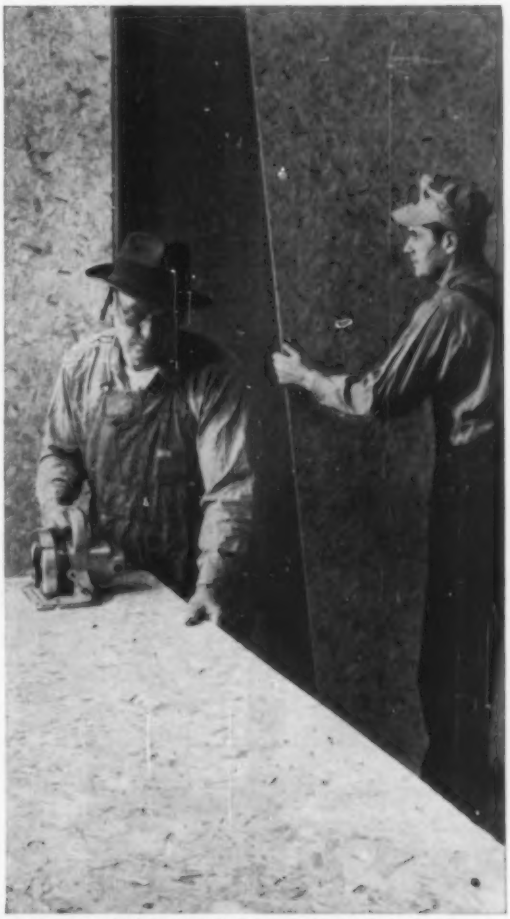
CYMEL* IN ELECTROSURGERY

High-frequency current flows between two sharp electrode tips in the 789 Bi-Active Coagulation Set used by physicians for removal of cervical cysts, tonsils and surface growths. The Birtcher Corp. of Los Angeles encases the electrodes in mineral-filled CYMEL Melamine Molding Compound because of its excellent insulating properties and smooth flow into the mold which simplifies accurate spacing of the tips. Handles and cord tips are molded of alpha-cellulose-filled CYMEL, also an excellent insulator. All surfaces are exceptionally hard, chip resistant and can be sterilized easily. *Trademark



MODERN TOUCH IN WIRING DEVICES

Home styling today favors light, cheerful colors. This note is carried out perfectly with wiring devices molded of ivory-colored BEETLE® Urea Molding Compound. Its hard, smooth surface resists discoloration and scratching, and safe dependable service is insured by BEETLE's excellent insulating properties.



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These attractive panels are made of wood particles bonded with MELURAC® Melamine-urea Resin. This low-cost particle board has good warp resistance, flexural strength, moisture resistance and easy working and finishing properties. In addition to structural uses—walls, sliding doors, partitions, ceilings, subflooring, parquet flooring—it is ideal for furniture core and underlayment of decorative melamine laminates. MELURAC 304, developed expressly for this use, imparts no color and improves strength of the particle board.

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Circle 103, inside back cover

High-Temperature Alloys–Booklet DB-52-250, 4 pp. Lists physical properties, applications and shape availability of Discaloy, K42B, Refractaloy, and Refractaloy 70. Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh, Pa.

Circle 104, inside back cover

Conversion Tables–Pocket Folder, 6 pp. These tables simplify conversion from decimal to binary numbers, and vice versa. 3½ x 8½ in. Barnes Engineering Co., 30 Commerce Rd., Stamford, Conn.

Circle 105, inside back cover

Variable Voltage Adjustors–Catalog VA 312, 4 pp. Describes transformers manually operated to maintain constant voltage. With specification and dimension charts. Acme Electric Corp., Cuba, N. Y.

Circle 106, inside back cover

Bimetal Thermostats–Bulletin 8400, 4 pp. Has information on temperature ranges, ratings, mountings, terminal arrangements. Includes handy temperature-conversion chart. Stevens Mfg. Co., Inc., 45 N. Plymouth St., Lexington, Ohio.

Circle 107, inside back cover

Volume Pumps–Bulletin 553-1, 32 pp. Specifications and latest design features of motor-driven controlled volume pumps. Standard and modified models and their applications are illustrated and described. Special feature section contains charts and reference information. Milton Roy Co., 1300 E. Mermaid Lane, Philadelphia 18, Pa.

Circle 108, inside back cover

Multi-Contact Relay–Engineering Bulletin, 4 pp. Comprehensive report on miniaturized Type 9 telephone relay. With descriptions, technical information, dimensional drawings, standard stock and contract listings for the relay. Phillips Control Corp., Joliet, Ill.

Circle 109, inside back cover

Truck Bumpers–Catalog Sheet, 2 pp. Has detailed specifications, photographs, engineering sketches on Flex-

(Continued on page 308)

Where leakproofing is critical...

CEC's Leak Detectors

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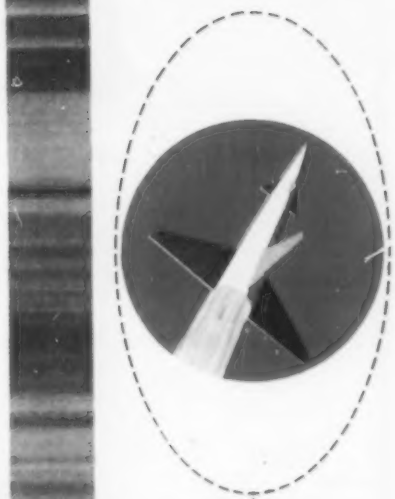
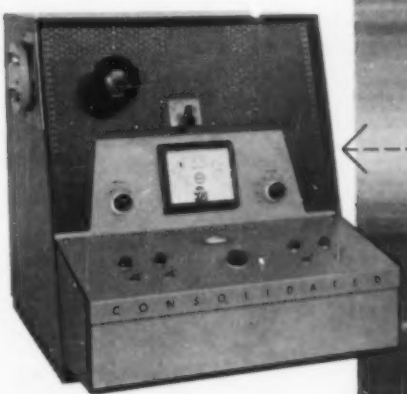
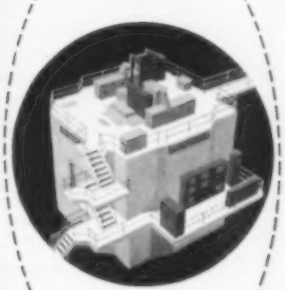


So dependable they're used to test out pressure systems of rockets and nuclear reactors. These sensitive instruments can serve *your* requirements equally well. Because CEC's Leak Detectors locate microscopic leaks *with mass-production economy,* these helium-sensitive mass spectrometers are preferred wherever vacuum or pressure leakproofing is critical. Easy, convenient operation requires no special training or experience. Find out how quickly these practical, long-life instruments pay for themselves. Contact your nearby CEC field office, or write for the Bulletins indicated.



24-210 Compact and portable, the economical 24-210 locates leaks so minute that 1cc would require 50 years to escape, or detects better than one part helium in 300,000 parts of air. Low cost with no sacrifice of reliability. Write for Bulletin CEC 1830-X26.



24-110 Ultra-sensitive, detects better than one part of helium in 2,000,000 parts of air. Recommended for requirements of large, complex, nuclear-reactor systems and high-vacuum products. Write for Bulletin CEC 1838-X11.

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O-Rubber truck bumpers. Bumpers, Inc., 2534 Detroit Ave., Cleveland 13, Ohio.

Circle 110, inside back cover

Wireway—Bulletin GEC-1426A, 4 pp. Gives applications and selection data on a new hinged-cover wireway. Also lists catalog numbers, ratings, dimensions and guide-form specifications. General Electric Co., Distribution Assemblies Dept., Plainville, Conn.

Circle 111, inside back cover

Motors—'57 Condensed Motor Catalog, 4 pp. This folder condenses 300 pages of essential data. Covers current pricing for 1/20 through 200 hp motors on general-purpose fractional and integral hp motors. Includes slide-base dimensions with diagrams and adapter information. Marathon Electric Mfg. Corp., Wausau, Wis.

Circle 112, inside back cover

Heating Problems—Technical data, folder. Solutions to heating problems arising from odd contour shapes, space and/or weight limitations with sprayed-on heating elements. Electrofilm, Inc., P. O. Box 106, N. Hollywood, Calif.

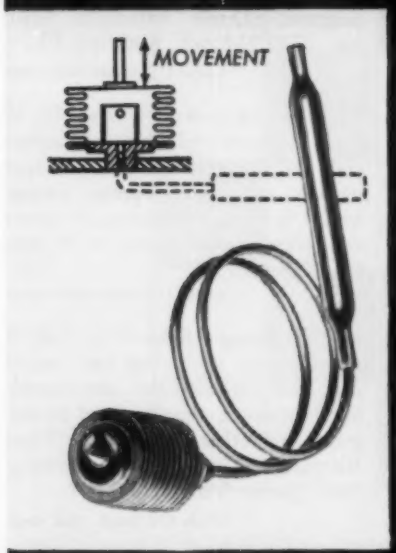
Circle 113, inside back cover

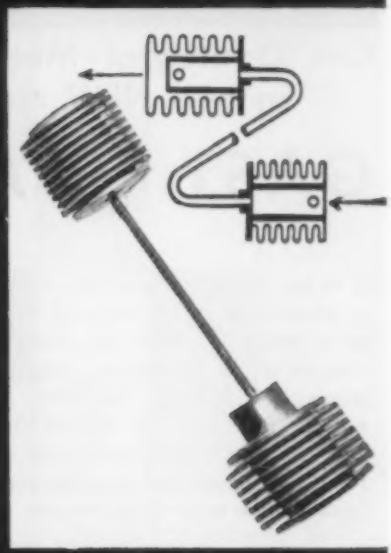
Wire, Cables—Catalog, 40 pp. Including an introduction to plastic insulation and its physical characteristics, this survey of products offered by the firm, as well as those made to customers' specifications, concludes with useful engineering tables. Phalo

(Continued on page 310)

"They worked on it together—now they're splitting up over a technicality."

TO CONVERT OR ABSORB THERMAL EFFECTS AT LOW COST SYLPHON BELLOWS AND ASSEMBLIES





Whether design problems involve thermal, pressure or mechanical effects, Fulton Sylphon can help you use the simple, foolproof bellows principle to best advantage. For one thing, an unmatched engineering service assures you of the *right* bellows or bellows assembly. Specialized skills and facilities also enable Fulton Sylphon to produce *complete* bellows assemblies at lower cost than you could yourself. And only from Fulton Sylphon can you get the extra know-how that comes from 52 years of experience with every conceivable bellows application!

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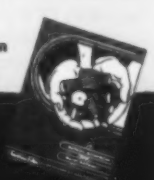

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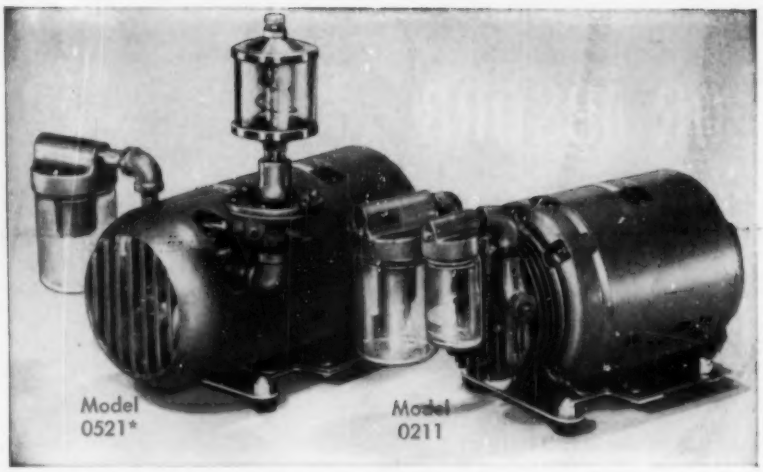

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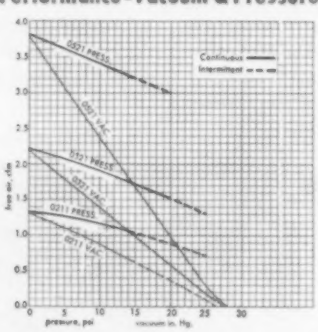

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- **VACUUM PUMPS** TO 28 IN.

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Catalogs and Bulletins.....continued

Plastics Corp., 25 Foster St., Worcester 8, Mass.

Circle 114, inside back cover

Wrappings—A 1957 list of protective wrappings and packaging materials meeting government specifications. Cincinnati Industries, Inc., Cincinnati 15, Ohio.

Circle 115, inside back cover

Automatic Tools—Bulletin, 4 pp. Describes standardized unit that can be combined with existing equipment to automate small parts assembly operations. Illustrated with photos and diagrams. Dixon Automatic Tool, Inc., 2300 23d Ave., Rockford, Ill.

Circle 116, inside back cover

Electrical Equipment—Catalog 57, 20 pp. Lists wires and cables, connectors and wiring harnesses, portable spot welders and wire strippers, voltage testers and commutator-maintenance equipment. Sittler Corp., 18 N. Ada St., Chicago 7, Ill.

Circle 117, inside back cover

Mercury-Plunger Relay—Fact File, 8 pp. Contains load-rating and contact data, coil characteristics, and mounting dimensions, supplemented by diagrams and other illustrations. Ebert Electronics Corp., 212-26 Jamaica Ave., Queens Village 28, N. Y.

Circle 118, inside back cover

Columbium and Tantalum—Booklet, 4 pp. Describes properties and applications of their high-temperature, abrasion-resistant alloys. Shieldalloy Corp., Newfield, N. J.

Circle 119, inside back cover

Voltage Regulators — Engineering Paper, 8 pp. Shows how corona-type regulators can solve special problems. Illustrated with performance curves, graphs, schematics. Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio.

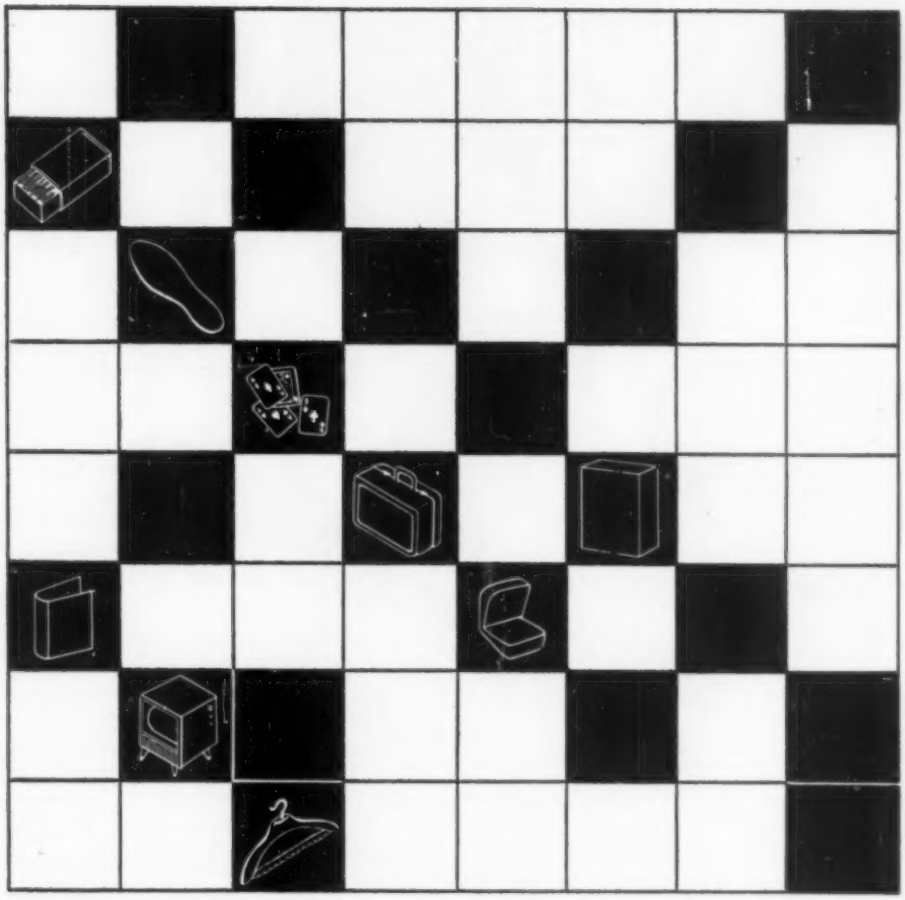
Circle 120, inside back cover

Pulse Calibrator—Brochure, 4 pp. Describes operation of the instrument; gives specifications; illustrates and explains actual waveforms. Burroughs Corp., Electronic Instruments Div., 1209 Vine St., Philadelphia, Pa.

Circle 121, inside back cover

Panel-Mounting Instruments—Catalog, 36 pp. Includes Designers' Guide

(Continued on page 312)



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This versatile material fabricates into almost any shape and lends itself to many new uses. In addition to making superior folding cartons and set-up boxes, Gair Boxboard excels as book covers, game boards, shoe innersoles, shelving, coat hangers, templates, chair seats, luggage boards, partitions, furniture and TV backs, and in dozens of other industrial and re-sale fabrications.

If you are designing a new product or improving an old one, Gair Technical Service will show you why it pays to create products and components with boxboard by Gair. Consistent high-quality in a great variety of grades, colors, coatings, laminations and treatments . . . fast delivery when and where you need it. Call your Gair representative or write Gair, today.

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SPRINGBOARD TO MORE SALES.

BOXBOARD AND FOLDING CARTON DIVISION OF CONTINENTAL CAN COMPANY

530 FIFTH AVENUE, NEW YORK 36, N. Y.

. . . this Complete
NEW Line of

HAYDON*
TIMING MOTORS

Here is a complete line of timing motors that includes the right choice for every APPLICATION . . . entirely re-designed for finer performance. Features include: slower basic rotor speed (450 rpm), controlled lubrication, total enclosure, smaller size, superior accuracy, quieter operation and longer life.

HYSTERESIS . . . *the ideal general-purpose motor.*

INDUCTOR . . . *extra torque (30 ounce inches) for display and other heavy-duty jobs.*

CLUTCH . . . *allows automatic re-setting without external clutches.*

REVERSIBLE . . . *a hysteresis type with 2 coils, each producing opposite rotation.*

DIRECT CURRENT . . . *a permanent magnet type for 6 to 32 volts.*

400 CPS . . . *miniature and heavy-duty models for airborne instrumentation.*

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A SUBSIDIARY OF GENERAL TIME CORPORATION

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with photos, outline drawings, description, theory of operation, mounting details, and complete specifications on the instrument line. Sectioned for easy reference.

The Designers Guide aids in the selection and application of VTVMs to measurement or monitoring problems and discusses the how-to phase of building electronic instruments into system equipment. Trio Laboratories, Inc., 4025 Merrick Rd., Seaford, N. Y.

Circle 122, inside back cover

Screen Resist–Booklet, 6 pp. Provides technical information on Supracote Blacktop No. 3, an improved screen resist for printed circuits. Techniques Sales Co., 52 Jackson Ave., Hackensack, N. J.

Circle 123 inside back cover

Tube Fitting–Wall Chart 4300C3. Steel fittings for connecting steel-tubing lines are pictured and identified by part name. Tube & Hose Fittings Div., Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio.

Circle 124 inside back cover

Letterhead Requests Only

Manufacturers who published following literature ask that requests for copies be made on company letterheads.

Tandem Strip Fasteners – Catalog sheets, 2 pp. For series 233, 234, and 235. Drawings of parts, showing all important measurements, plus data on materials, parts numbers, min and max dimensions, length, width, and thickness. Prestole Corp., 1345 Miami St., Toledo 5, Ohio.

Timing Devices–Catalog-Manual, 25 bulletins. Loose-leaf binder holds color-coded bulletins. An index legend sheet in front of the catalog guides the user. Among the units described are repeat-cycle timers, time-delay relays, elapsed-time indicators, stop clocks; also a-c, d-c and chronometrically-governed timing motors and relays.

Along with the detailed descriptive matter are 60 photos, 30 dimensional drawings, 50 charts and diagrams, and approximately 600 parts numbers. Dept. RWP, A. W. Haydon Co., 232 N. Elm St., Waterbury, Conn.

NEW GOLDEN BONDERITE for Aluminum

Uniform color means uniform coatings and uniform efficiency

It's the simplest thing in the world to check on the efficiency of a Golden Bonderite installation. Just look at the color of the aluminum as it comes out of the Bonderite machine. The uniform golden coating looks the same—and it is the same—24 hours a day, seven days a week.

Golden Bonderite sets entirely new standards of efficiency and performance as a paint base for aluminum and its alloys. Operated with the Parker "Reactifier," the Golden Bonderite solution can be used indefinitely, ending the costly necessity of dumping the bath at frequent intervals. Normal chemical replenishment keeps the Golden Bonderite solution in continuous balance.

This ease and certainty of achieving uniformly excellent results means real savings for aluminum fabricators.

It guarantees an effective base for paint.

It breaks the finishing line production bottleneck.

It saves money on chemicals.

It saves money on rejected parts and minimizes field calls because of finish failures.

There are no limitations on the use of new Golden Bonderite. It may be applied by spray or immersion. Treatment cycles can be set to suit production speed and equipment.

Samples of Golden Bonderite-treated aluminum, plus test data, are available for your inspection. Write or call.

How Parker "Reactifier" Works

In conventional surface treatments of aluminum, work passing through the solution causes a buildup of impurities. As impurities increase, solution efficiency decreases until there's nothing to do but dump the bath and start over.

The Parker "Reactifier" removes these impurities as fast as they are formed in the Golden Bonderite solution. Constant circulation of the Golden Bonderite through the exclusive "Reactifier" means a balanced, efficient solution that can be used indefinitely.

Write for Bulletin in COLOR!

Get your copy of the descriptive bulletin on Golden Bonderite and its companion, Green Bonderite, for aluminum. It's new!

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BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

**Bonderite, Bonderlube, Parco, Parco Lubrite, —Reg. U.S. Pat. Off.*

Cold Heading Cost Savings

Actual Cost Cuts As High As 70%

The most important consideration we can point out to the designer or purchaser of fasteners and small parts is that any part which can be machined from rod stock is also potentially available from the cold heading manufacturer. This technique offers speed of production, without scrap loss, plus superior strength and appearance for low cost and high design efficiency.

The designer need not be restricted to standard fastener sizes when they do not meet the requirements of his application. It is often much less expensive to specify a rivet, nail or screw to meet the task exactly as the application requires, than it is to compromise its function for the sake of "standards." While there is nothing mysterious about the cold heading process, experience has proved it to be of inestimable value for getting maximum quality and output at a minimum cost. While the really spectacular advantages in cost show up in runs of several thousand pieces, we are also able to take care of short run requirements. We welcome and expect manufacturers to come to us for advice and assistance concerning their fastener problems.

Given complete specifications, including a drawing and an idea of the application, we can quickly tell you whether or not it will be advantageous to have your fastener or part JOB-DESIGNED by HASSALL. The remaining important aspect of our service to you is the ability to get into production quickly and make prompt shipment.

Write for a copy of our new booklet, "What the Designer Should Know about Cold Heading".

John Hassall, Inc.

P. O. Box 2233

Westbury, Long Island, N. Y.

Tangents...

Whistle While You Work

"Nothing about a diesel locomotive will ever be as nostalgic as the sound of a distant steam-engine whistle when you're in bed at night." This remark was made by a diesel man at what was, surprisingly enough, a nostalgic occasion for diesels.

The scene was a passenger coach behind No. 1000, first successful diesel locomotive, on her last run before honored retirement to the B & O Museum in Baltimore. It was the first time Old 1000 ever pulled passenger coaches, because she is a 300-hp switcher, pretty puny by today's standards (see cover). Yet, when she went into service 32 years ago at the Bronx (N. Y.) yard of the Jersey Central Railroad, she was the first diesel locomotive anywhere—and incorporated the first high-speed engine. (Speed was 600 rpm—almost three times conventional speed then.) Knowledgeable railroad men predicted she'd fly apart, hooted about her boxy look, were sure she couldn't be economical—even though she'd made her 470-mile delivery run from Erie, Pa., to Phillipsburg, N. J., on 110 gal of fuel, costing $5.50, in 16 hr.

But No. 1000 fooled her critics. Her operating costs were about a third, maintenance a half, and utilization factor (80%) twice that of a comparable steamer. That was the death knell for the steam engine, nostalgia notwithstanding.

"Well you go tell Sales if they want it redesigned with fishtail fins to find themselves a new boy!"

No. 1000 is still in operating condition, but her 300 hp are just not enough for today's switching. Modern switchers weigh 167 tons, instead of her 60, and deliver eight times the horsepower. So the first diesel locomotive, built 32 years ago by Alco Products, General Electric, and Ingersoll-Rand, is already a museum piece.

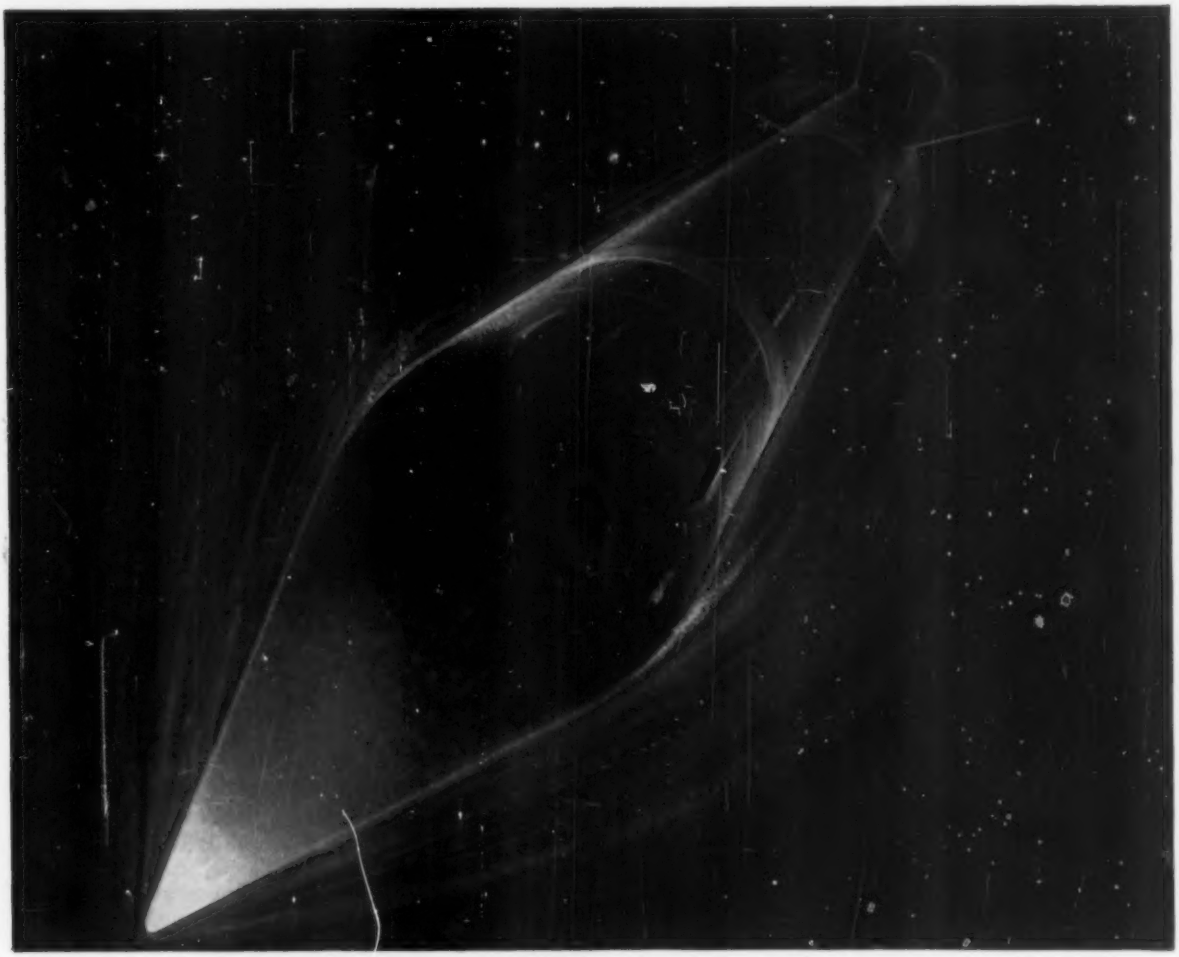
The sound of a steam whistle has power to drag the memory. I remember, for example, that my father, then chief (stationary) engineer for Fitz Hugh-Luther Locomotive Co., had several tricks with the plant whistle. We lived a half-mile or so from the plant, and had no telephone, so my father would signal my mother as to his plans when he blew the stopping whistle at six o'clock. One long blast meant he'd be home on time, twin toots meant he'd be a little late, a long-and-short meant he'd be very late.

Most plant whistles don't blow now except for fire. Electric clocks have outmoded their job of providing a local time check, and modern workmen resent the regimentation suggested by the sound.

Here we have a paradox—men are nostalgic for the train whistle at a distance, but are happy to miss the nearby factory whistle. So nostalgia apparently includes no shreds of a sense of duty. And in spite of its supposed power to motivate people, railroad men show no tendency to return to steamers. Nor do firemen agitate for a return to horse-drawn fire engines, complete with steam boiler. Stirring sights they were, but not nearly so efficient as the modern truck at fighting fires.

Back at Christmastime of 1930, when *Product Engineering* was young, I was assigned to write a story with Christmas flavor. I chose toy trains, because they involve so much engineering design. The old American Flyer Company agreed to cooperate. In the course of my conversations with

(Continued on page 316)



Sustained operating temperatures up to 400° F, as in guided missiles, are death to inferior electrical insulations and laminates. CDF glass-base laminates of Teflon*—the only laminates of their kind approved by the military—can take this punishment steadily.

LATEST HIGH-HEAT INSULATION SYSTEMS NEED CDF GLASS-BASE LAMINATES AND TAPES

Widest available range offers Teflon, epoxy, silicone, mica products for dimensional stability under continuous heat

As components and equipment grow smaller, and heat becomes more difficult to dissipate, CDF high-heat electrical insulations become increasingly important to electronic design. For nowhere else can such a wide range of quality insulations be found under one roof as at CDF.

FOR HIGH-HEAT PRINTED CIRCUITRY, CDF glass-base metal-clad laminates of Teflon* and epoxy exhibit best dimensional stability and current-carrying capacity. Constant operating temperatures of 300°F — soldering temperatures to 500°F — are readily met by these specialized CDF Dilecto® laminates.

HIGH-HEAT FLEXIBLE INSULATIONS. CDF offers a wide choice of insulating tapes made of Teflon, silicone varnish, silicone rubber, and Micabond®, with glass-cloth support. CDF tapes may be used either by hand wrapping or on automatic winding machines. Unsupported Teflon in colors available to meet MIL-STD 104.

TEFLON SPAGHETTI TUBING AND OTHER SPECIALTIES. Part of CDF's vast fabrication facilities is devoted to the production of custom parts from Teflon — spaghetti tubing, rods, sheets, and machined parts to rigid specifications.

NEW — *cementable* Teflon, bondable to itself and to other materials with commercial adhesives.

SEE SWEET'S Product Design File, Electronics Buyers' Guide, and other directories for the name and phone number of your CDF sales engineer. Then send your print or your problem, and we'll return specific technical data and test samples.

*trademark of DuPont tetrafluoroethylene resin

CDF **CONTINENTAL-DIAMOND FIBRE**

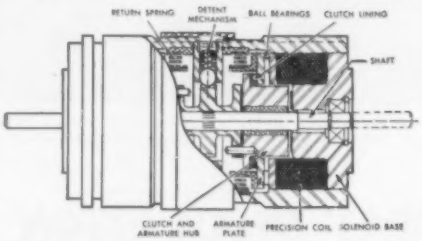
A SUBSIDIARY OF THE Bndd COMPANY • NEWARK 40, DEL.

NEW! Syncramental motor provides precise bi-directional stepping

ACTUAL SIZE

The *Syncramental* Motor accurately translates pulses to incremental shaft position for conversion of digital information to analogous shaft displacements. Compact, long-life power can rotate potentiometers, counters, rotary switches, control mechanisms.

A special magnetic clutch mechanism, rather than ratchets, indexes the shaft. Clutch and detent mechanism are mounted between two Ledex Rotary Solenoids whose armature plates face each other. Clutch rotates with one or the other of the energized armatures, to which it has been magnetically attracted, causing shaft rotation. Solenoid de-energizing returns the armature to original position, but clutch and shaft are held in displaced position by the detent.



PERFORMANCE: Angular increment per pulse—36° (either direction). Detent accuracy—±½° under no load conditions. Maximum stepping rate—15 per second. Load capacity—up to 2 lb. in. starting torque at 20°C. Life expectancy—2 million steps in either direction.

ENVIRONMENTAL CONDITIONS: Temperature—minus 55°C. to 120°C. Altitude—up to 90,000 ft. Meets applicable requirements of MIL-E-5272A.

SIZE, MOUNTINGS: Dimensions—1.500" dia. x 2.525" long. Weight—13 oz. Mountings—standard Servo.

Write today for complete data...

SYNCRAMENTAL MOTOR

G. H. Leland INC.

123 WEBSTER STREET, DAYTON, OHIO

IN CANADA: Marsland Engineering Ltd., Kitchener, Ontario

IN EUROPE: NSF Ltd., 31-32 Alfred Place, London, England

the general manager, he mentioned that new features made a tremendous difference in sales, because both boys and their fathers were attracted by such gadgetry. A few years earlier, Lionel had introduced Mickey and Minnie Mouse operating a hand car on a track—and sold them by the thousands. Another year, American Flyer added a mailbag catcher. Still another year, it was lights in the coaches. And, just previously, the big sales point was smoke pellets, so the engine puffed realistically. Basically, both designs were good—but the gadgets determined who'd made the best record each year.

Said I: "If a sales gadget makes sales, the absence of it could break a company. What gadget, still to be added to a train, would make a fortune for the company that gets it—and break the competitor?" Said he: "A train whistle that sounds like a real one would do it. We already know how to operate one electrically at crossings, but we can't get the right sound. If one company whips that, the other is in real trouble."

A year or two later, Lionel perfected a toy-train whistle that sounded like the real thing. Shortly afterward, American Flyer was sold to Gilbert.

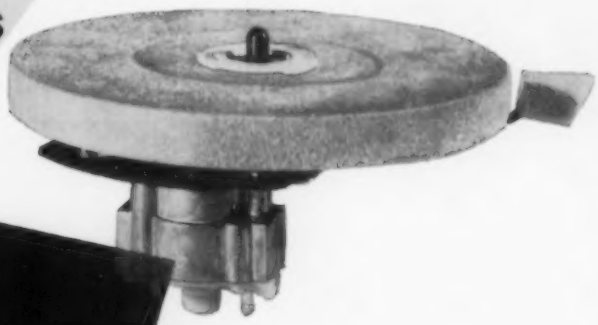
So perhaps, nostalgia was strong enough to make the buyers break a toy-train company because it lost in the race to develop a whistle. And that nostalgia was probably increased by the unromantic full-size diesel with raucous Klaxon horn. But it was more efficient than its steam-whistled counterpart, and that's what counted—not nostalgia. Nobody is willing to pay too much for his whistle. **—E.J.T.**

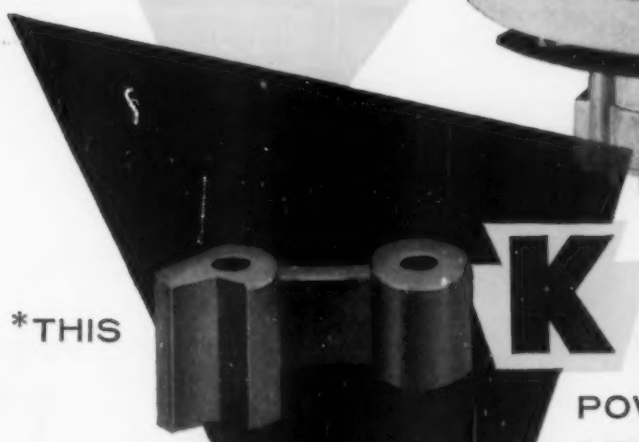
"Certainly is an attractive pressure switch. I'll have to design some sort of a product to use it."

FOR **ALLIANCE** MANUFACTURING COMPANY, INC.

BATTERY-DRIVEN

PHONOMOTORS





*THIS **Keystone** POWDERED METAL **IDLER LINK**

Provides

CLOSER TOLERANCES
EXACT HOLE ALIGNMENT
LONGER CAMMING WEAR
ELIMINATION OF DRILLING and REAMING

. . . AT SUBSTANTIAL COST SAVINGS PER UNIT

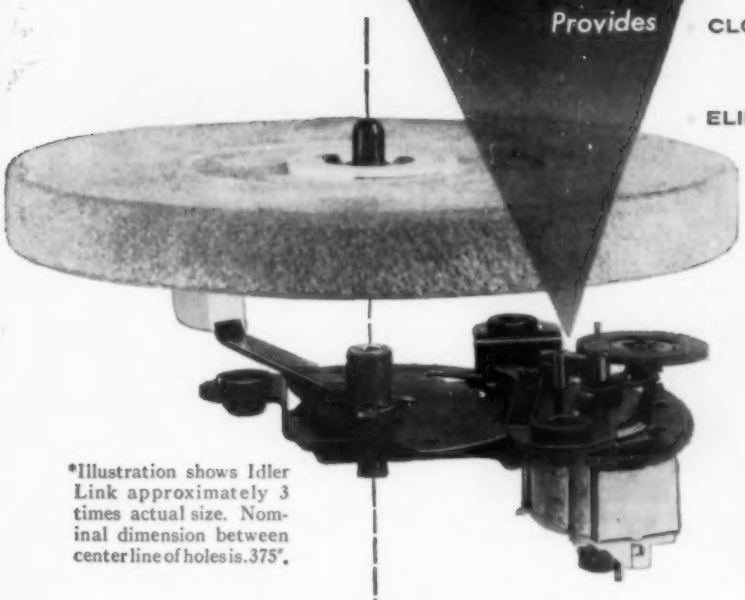


*Illustration shows Idler Link approximately 3 times actual size. Nominal dimension between center line of holes is .375".

Music on records, wherever you go, is delivered by today's lightweight, portable phonographs powered by flashlight batteries. And at the heart of many of these popular units you'll find a dependable Alliance phonomotor-turntable assembly . . . providing accurate 3-speed operation at low battery drain.

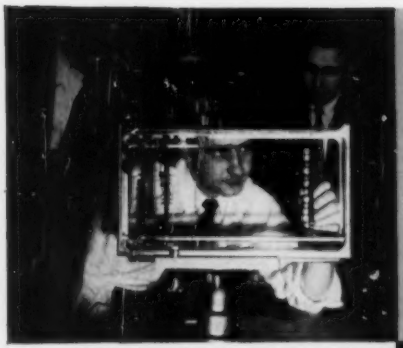
The Keystone powdered metal idler link is essential to the smooth operation and long life of the Alliance unit. It functions as a swivel in the idler drive, and as a raising and lowering member in speed changing for the various record types.

Designed originally for die casting, the part formerly required drilling and reaming to close tolerances and hole alignment, with a high scrap factor and production-delaying tool maintenance.

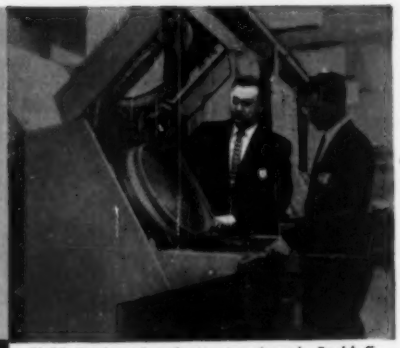
Now, with Keystone powdered metal fabrication, even closer tolerance and alignment are gained without machining—in a single forming operation, at high production rates. Longer wear life and excellent cost reduction are provided into the bargain.

Why not check with KEYSTONE now on the advantages powdered metal can bring to the fabrication of parts in your product. Contact us today.

Keystone
CARBON
COMPANY
Powdered Metals Division
ST. MARYS, PA.



Associate Engineer Donald A. Patterson demonstrates a problem in pluggable unit layout.



Field Engineering Instructor Joseph Rechloff explains basic display console functions at IBM, Kingston, N. Y.

Associate Engineer Robert M. Blake points out a feature of an advanced magnetic tape circuit development.

You'll find a new challenge DEVELOPING the world's largest computers at

IBM Kingston

Staff Engineer Michael S. Zucker and associates plan electronic digital computer systems.

The design and development of SAGE (Semi-Automatic Ground Environment) computers, part of our nation's radar defense system, offer stimulating new challenges to creative engineers at IBM Kingston.

Projects currently in process include: Digital and analog systems . . . advanced circuitry . . . electronic packaging . . . communications engineering . . . simulation studies . . . air traffic control . . . automation.

If you are an electrical or mechanical engineer, a mathematician or a physicist—and want to do development work—you owe it to yourself to investigate the exciting possibilities that SAGE computers offer you at IBM Kingston.

Computer Student Stanley J. Ostrowski studies wave forms in the IBM Computer Engineering School laboratory.

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Plants and laboratories: Endicott, Kingston, Owego, Poughkeepsie, N. Y.; Lexington, Ky.; Rochester, Minn.; San Jose, Calif.

Skinner Solenoid Valves are easier to maintain and service because of their simplified design

The man shown above is cleaning a Skinner Solenoid Valve. He has disassembled it by hand without removing it from the line. Simplicity of design makes this simple maintenance and service feature possible. The design of Skinner valves is such that coils and other parts are interchangeable and easily, quickly replaced. They are readily available, too — reducing the stocking of spare parts to a minimum.

Skinner Solenoid Valves are made of the very finest materials available and contain only two moving parts. Their joints are heli-arc welded on special electronically controlled equipment. Their coils, manufactured to UL standards, will operate for years without burnout. Their positive spring returns eliminate sticking. And they have no packing to wear out and cause leakage.

If you are looking for solenoid valves that will give you longer trouble-free performance, look to Skinner valves. For complete information on Skinner's line of 2-, 3- and 4-way valves, write us or contact a Skinner representative. Write Dept. 458

Skinner Solenoid Valves are distributed nationally

SKINNER ELECTRIC VALVES

THE CREST OF QUALITY

SKINNER ELECTRIC VALVE DIVISION

NEW BRITAIN CONNECTICUT

105 EDGEWOOD AVENUE

Tough
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STRAIN
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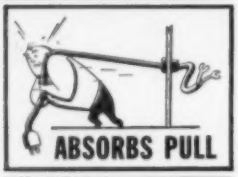
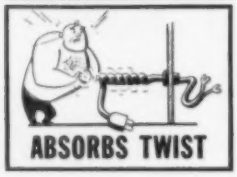
Insulate and anchor the power supply cord to your housing . . .
no need for grommets, wire knots or costly labor.





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DESIGN ABSTRACTS

Fiber Metallurgy

Metallic fibers can now be worked into felt-like materials with controlled porosity ranging up to 95%. These materials extend the applications of powder metallurgy to fields that could not otherwise be explored.

Felting techniques are necessary with metal fibers because their geometry imparts to them very poor flow characteristics.

Commercial sources of fibers are metal wools and wire. New metal fiber sources are expected to be available soon utilizing processes which will bring the cost of metal fibers to within a few cents of ingot market price.

Formation of an isotropic structure is dependent upon cutting of metal wool to uniform lengths. Cutting is performed on automatic machinery which reduces the fibers to ⅛ or ¼ in. lengths.

Felting is normally performed with the fibers submerged in liquids, like slips, and occurs when the carrier is drawn away from the suspension.

Sintering of the felts gives rigidity to the fibrous body. Optimum mechanical properties of the materials have not been determined.

Abstracted from, "Fiber Metallurgy" by C. H. Sump and W. Pollack, Proceedings of the Metal Powder Ass'n., 130 W. 42 St., New York, N. Y.

High Temperature Nickel-Base Alloys

Tests to determine the 100-hour rupture strengths of five nickel-base alloys in sheet form at 1200 and 1350 F show that:

1. The best nickel-base sheet alloys have greater 100-hour rupture strengths at 1200 and 1350 F than other oxidation resistant sheet alloys for which data are available.

2. Of the nickel-base alloys studied, Inconel 700 and Incoloy 901 were strongest at 1200 F. Strongest at 1350 F were Inconel 700 and R-235.

3. Precipitation-hardening heat-treatment strengthened all five alloys when tested at 1200 F, while at 1350 F only Inconel X, Inconel 700, and R-235 were strengthened.

4. Nickel-base sheet alloys generally lack the ductility of cobalt- and iron-base sheet alloys.

5. Stress-rupture fractures generally occur in the grain boundaries.

6. Heat-treatment raises the strength of sheet in most cases, although not to the level of heat-treated bar stock.

Abstractted from "Rupture Strength of Several Nickel-Base Alloys in Sheet Form," by James H. Dance and Francis J. Clauss, Lewis Flight Propulsion Laboratory, Cleveland, Ohio, National Advisory Committee for Aeronautics Technical Note 3976, April 1957.

Oil Seals to Provide Positive Lubrication on Large or High-Speed Thrust Bearings

Vertical waterwheel generators are provided with large thrust bearings the surfaces of which are separated by a hydrodynamic oil film. In order to insure the formation of the required oil film, a continuous and sufficient supply of oil is required. With thrust bearings of increased size or speed, aeration of the oil may cause inadequate lubrication of the bearing surfaces or result in oil leakage.

This paper discusses the application of positive oil seals which effectively prevent aeration of the oil and oil leakage. It concludes that the bearing surfaces of vertical waterwheel-generator thrust bearings are separated by an hydrodynamic oil film which supports the weight of the rotating parts.

On high-speed machines the oil in the bearing reservoir may become aerated to a considerable extent by tubulence at the bore and the periphery of the thrust bearing. Such aeration of the oil may interfere with the formation of the desired oil film.

The proper application of laminar fluid seals at the bore and periphery of the thrust-bearing runner and the maintenance of positive pressure at

(Continued on page 322)

"Why substitute? The best metal for screw machine parts is still brass... and it costs less!"

Titan Brass Rod

REDUCED 30%

Price of Titan free-cutting brass rod today is reduced over 14¢ or 30% from April 5, 1956 . . . from $47.51/lb. to $32.87/lb. on July 16, 1957.

Be cautious about substitution claims. Remember these advantages of brass:

- Brass is the most easily machined of all metals . . . giving low costs and high output
- Brass allows trouble-free maintenance on screw machines
- Brass has natural fine surface for high polish and ready plating
- Brass gives maximum production efficiency . . . eliminates extra operations
- Brass is corrosion-resistant
- **Brass scrap has the highest market value of all common metals**

It all adds up. Brass gives you your metal money's worth! And brass costs less. Call Titan today!

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Depots: Bellefonte and Indianapolis

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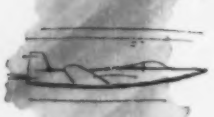
for

CORROSION-RESISTANCE, PAINT BASE on ALUMINUM and MAGNESIUM

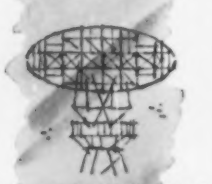
TYPICAL APPLICATIONS



Aircraft and Missile Parts

Automobile Hardware

Outdoor Furniture



Communications Equipment

Marine Equipment

EASE OF USE—Iridite is a simple chromate conversion treatment. Fast, easy, economical. You just dip, brush or spray it on the part at room temperature. No special equipment. No specially trained personnel.

OUTSTANDING PERFORMANCE—Forms a film that is an integral part of the metal itself. Can't flake, chip or peel. Takes paint firmly on initial application, and the bond lasts. Even protects areas scratched in use.

LOWEST COST—You have only minimum equipment cost, no special racks, high speed operation, lower overall handling costs.

CHOICE OF APPEARANCE—Clear coatings that retain metallic lustre to dark, maximum protection coatings. A variety of colors is available by dyeing.

IRIDITE #14 and #14-2 (Al-Coat) for ALUMINUM

Two specially formulated finishes that give you maximum latitude in aluminum treatment. Both provide excellent corrosion protection and paint base. Iridite #14-2 is an improved product that allows greater flexibility in operation and coating thickness and produces the optimum in corrosion protection.
Either coating provides corrosion resistance superior even to complicated electrolytic treatments in a fraction of the time. These coatings also offer many other valuable characteristics: they have low electrical resistance, they aid in arc-welding, provide a good base for bonding compounds, have no effect on the dimensional stability of close-tolerance parts. Final appearances ranging from clear through yellow iridescence to full brown can be obtained. By dyeing, you can produce red, green, blue, orange or yellow finishes.

IRIDITE #15 for MAGNESIUM

Produces a protective, paint base film with corrosion resistance at least equal to that obtained from long, high-temperature dichromate treatments in a fraction of the time and at room temperature. The appearance of the coating can be varied from light brown to dark brown and black.

APPROVED UNDER GOVERNMENT AND INDUSTRIAL SPECIFICATIONS

SEE FOR YOURSELF WHAT IRIDITE CAN DO . . . SEND SAMPLE PARTS FOR FREE PROCESSING. Look at the results, test the protection, evaluate the savings. Also write for handy Reference File of the most complete data published on chromate conversion coatings. Or, for immediate information, call your Allied Field Engineer. He's listed under "Plating Supplies" in your classified phone book.

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Manufacturers of Iridite Finishes for Corrosion Protection and Paint Systems on Non-Ferrous Metals; ARP Plating Chemicals.
West Coast Licensee—L. H. Butcher Co.

these seals effectively prevent aeration of the oil in large and high-speed thrust bearings, thus assuring adequate lubrication.

Abstracted from "Oil Seals to Provide Positive Lubrication on Large or High-Speed Thrust Bearings," by R. A. Baudry and G. E. Peterson, The American Society of Mechanical Engineers Paper No. 57-SA-74, presented at the ASME semi-annual meeting, San Francisco, Calif., June 9-13, 1957.

High Temperature Hydraulic Pump Development

High temperature hydraulics are here to stay. The 450 F, 150 hour hydraulic pump is a reality. The 400 F, 560 hour pump is in the foreseeable future. The 550 F, 50 hour pump should be not much more than six months away. Pumps for operation at temperatures up to 1000 F are reaching the testing stage.

We have learned many things about high temperature circuits, and I would like to pass along our observations in the hope that they will help others to avoid the pitfalls.

Pumps

Overall pump efficiency plays a major role in determining reliability, circuit temperature, and, in some cases, circuit weight. Every effort should be made to make the overall pump efficiency as high as possible.

Seals

In all static seal applications in our pumps, we have eliminated the elastomeric seal in favor of the metallic O-ring. Elastomeric compounds tested at the high temperatures, with the possible exception of Viton "A,' have exhibited pronounced compression set. This results in seal leakage when a high temperature run is followed by cooling. For dynamic seals, Viton "A" is relatively new and shows promise.

Reservoirs

All systems operating above 200 F should incorporate airless reservoirs. If pneumatic pressurization is used, an inert gas, such as nitrogen, is best. However, the best reservoir arrangement has no free surface. For engine hydraulic systems, the hydraulic system should not operate directly from

(Continued on page 325)

The bearings you need when you need them

Whatever your ball bearing needs, investigate the advantages BCA offers. You get engineering assistance based on nearly 50 years' experience designing and manufacturing ball bearings . . . production flexibility to handle both emergency and routine situations . . . delivery when promised to keep your production lines moving. When you do business with BCA, you get the bearings you need . . . . when you need them. Bearings Company of America Division, Federal-Mogul-Bower Bearings, Inc., Lancaster, Pa.

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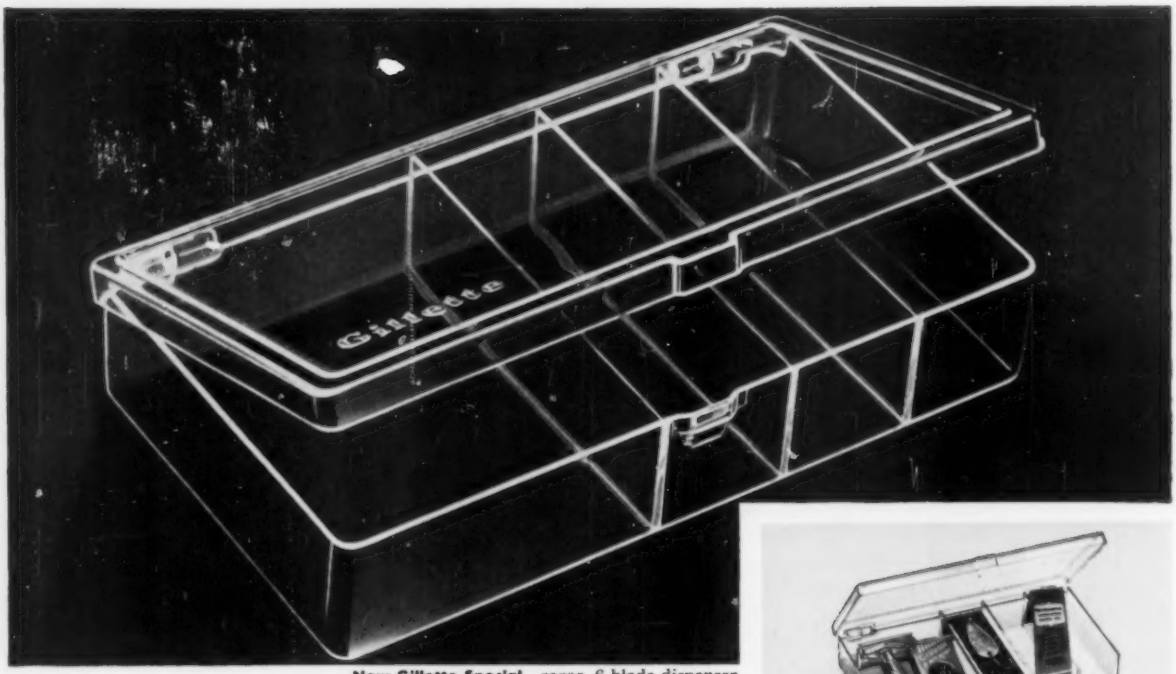
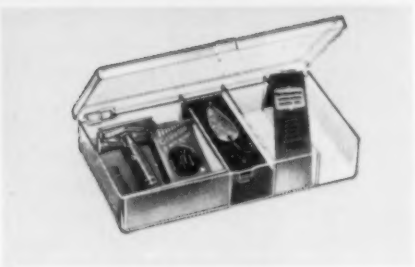


New Gillette Special—razor, 6-blade dispenser and gold-plated lure packed in a plastic box fishermen and handymen will find useful.



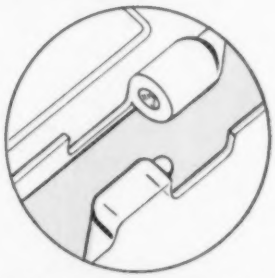
A Bright new idea in gift packaging by Gillette —custom molded by Sylvania

Chances are you're one of the many hundreds of thousands of fathers or fishermen to get a Gillette razor in the new plastic box gift case. If so, you've had a good close look at Sylvania injection custom molding.

You might have noticed that despite deep, thin-walled compartments, surfaces were smooth and clear and that in traditional Gillette fashion, the hinged top was securely latched but opened easily. And you probably guessed that the case was produced in high volume to meet the needs of America's gift-giving families, and Gillette shaving fathers.

A job like this calls for molding experience, facilities, and ingenuity characteristic of Sylvania. That's why manufacturers large and small take their custom-molding problems to Sylvania. Why don't you?

Write for this new brochure. It outlines Sylvania's complete custom-molding facilities, and might suggest how they can be put to work profitably for you. Write for information, too, on Sylvania's custom metal stampings; clad, plated and alloy wires; plated metal strip; custom wire welds, and special electronic components.



Snap-on hinges make it possible to mass-produce this Gillette polystyrene box in two pieces, quickly and economically snapped together to form the complete unit. Sylvania's ability to hold close hinge tolerances was an important factor in making this simplified design.

Sylvania's complete plastics services include mold making, compression, injection and transfer molding, and finishing and assembly operations.

SYLVANIA PARTS DIVISION

Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania

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SPECIAL WIRE | METAL STAMPINGS | MOLDED PLASTIC | ELECTRONIC COMPONENTS

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the engine sump. Though engine oil makes an excellent hydraulic fluid at high temperatures, the two uses are not compatible. When passing through the engine oil is exposed to extremely high temperatures in hot spots which causes rapid degradation of the oil. Engine oil is also exposed to air and other gases which cause a sludging effect.

Filters

At temperatures above 275 F the phenolic filter elements are troublesome. We have found that sintered stainless steel filters with 10 micron filtration provide adequate protection for the hydraulic circuits.

Fluids

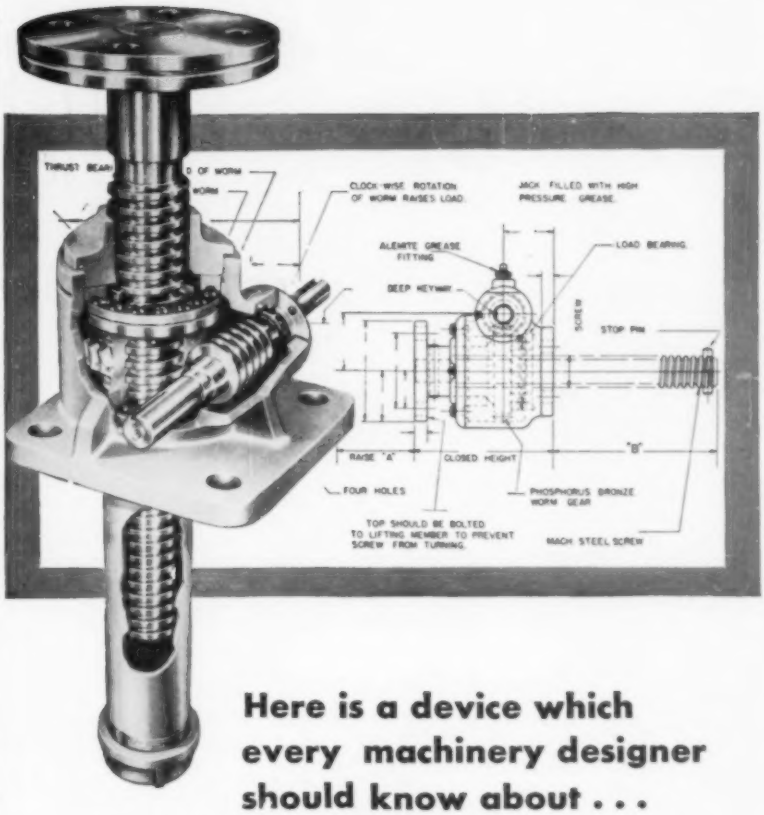
Tests have shown that lubricity is by far the most important property required of a hydraulic fluid. Other properties such as viscosity, viscosity index, and fluid life at high temperature, could be sacrificed if a substantial increase in fluid lubricity were obtained. It shouldn't be too much of a problem, in a properly designed circuit, to completely drain and flush the system at frequent intervals if this inconvenience increased the reliability and durability of the entire hydraulic circuit. Certainly the requirement for a pumpable viscosity at −65 F could be one of the first properties sacrificed in the search for an adequate high temperature hydraulic fluid. It is always possible to design heaters for warm-up at extremely low temperatures.

Abstracted from "High Temperature Hydraulic Pump Development," by W. S. Bobier, Vickers, Inc.

Work Capacities of Energy Storage Systems on Basis of Unit Weight and Unit Volume

In view of current and anticipated interest in conserving weight and space in engineering applications, a study is made of work-per-unit-weight and work-per-unit-volume moduli for energy storage systems. Gasoline engines, solid propellants, electrochemical cells, flywheels, compressed gases, compressed liquids, and stressed solids

(Continued on page 328)



Here is a device which every machinery designer should know about . . .

DUFF-NORTON WORM GEAR JACKS

Duff-Norton worm gear jacks provide a purely mechanical means for accurate positioning of loads weighing as much as several hundred tons and maintaining them indefinitely without creep. They will operate in any position, and functioning as components of machinery and equipment they can raise and lower loads, apply pressure or resist impact. Jack capacities range from five to 50 tons. When two or more jacks are connected by means of shafting and mitre gear boxes they lift in unison, even when the load is unevenly distributed. They are available with standard raises up to 25 inches, and will provide exactly the same raise for years without adjustment. Worm gear jacks are suitable for operation at ambient temperatures up to 200°F.

Thousands of these jacks are in use on feeding tables, tube mills, welding positioners, pipe cut-off and threading machines, testing equipment, aircraft jigs, loading platforms, rolling mills, conveyor lines, arbor presses, and numerous other types of equipment. If you have a positioning problem, write for complete information, requesting bull. AD-34-DD, which includes drawings and full specifications.

DUFF-NORTON **Duff-Norton Jacks**

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Moisture-laden hot-spot calls for some cool figuring!

Superior design of Louis Allis electric motors pays off under severe heat-humidity conditions

This paddle-agitator drive gets a steady bath of searing hot vapors from the trough below. Yet, the Louis Allis motor has given continuous and reliable service. Here are the special design techniques that make this possible:

Special attention to insulation—Louis Allis sponsors continuous research into new insulating materials. One example: Louis Allis engineers were first to combine Gilsonite with phenolics and alkyds. The result is a varnish with the highest degree of moisture, acid, and alkali resistance — extra-long life for all motor uses whatever your design problem.

Special care in manufacturing—Quality control of all materials . . . careful inspection . . . rigid test . . . all of these add up to the highest quality standards in the industry to assure you of continuous fine performance, dependability under any condition.

These and other Louis Allis extras—such as locked bearings for longer wear, positive lead identification for easier maintenance, and dynamically balanced rotor for quieter operation — could be the answer to your special design problems.

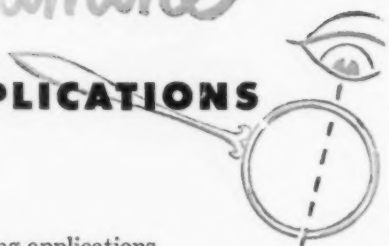
The complete story is in our Bulletin 1700. May we send it to you? Contact your nearby Louis Allis District Office or write The Louis Allis Company, 426 East Stewart Street, Milwaukee 1, Wisconsin.

LOUIS ALLIS

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE-SPEED DRIVES

time to re-examine

BEARING APPLICATIONS

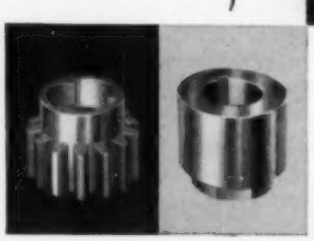


Striking cost reductions in bearing applications in many mechanical products are made possible by the use of Bunting Sintered Powdered Metal Bearings and parts.

Bunting engineering counsel can guide you in the selection of designs and alloys that will provide bearings of exactly the type, design and material that will fully meet both cost and functional requirements, whether the material be Cast Bronze or Sintered Metal.

A competent group of Bunting Sales Engineers in the field and a soundly established Product Engineering Department put at your command, comprehensive data and facts based on wide experience in the designing and use of Cast Bronze and Sintered Powdered Metal Bearings and parts.

Write for catalogs and your copy of the new 24 page Bunting Engineering handbook of Sintered Powdered products and their composition, manufacture and application.



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are evaluated. General analytical expressions for the work moduli are derived. For each such general expression, significant optimizing parameters are selected and methods of optimizing the moduli are presented. Information is included pertinent to the problem of selection of energy storage systems for specific applications. Comparisons are made of the practical maximum values of weight and volume moduli for the considered systems. Limitations of the systems, including maximum allowable stress, are discussed.

General Observations

The gasoline engine is one of the best work-producing devices from the standpoint of weight and volume modulus. The weight modulus for a gasoline engine is about 4.5 times that for the next best work-producing device considered. The volume modulus is about 6.5 times greater than that of the silver-zinc electrochemical cell. These results are due to the energy being stored in a highly concentrated form in the fuel.

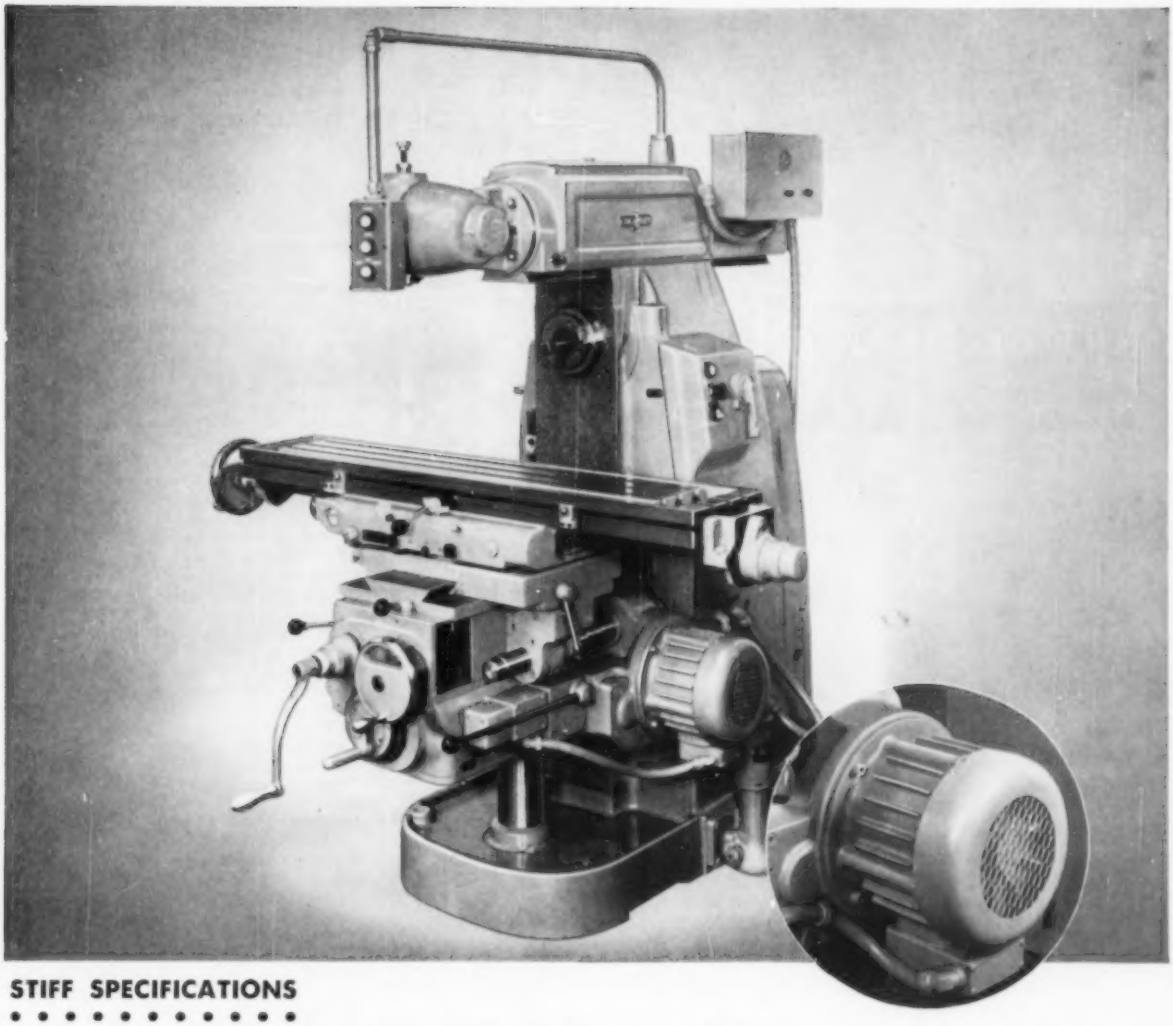
If electrical energy is desired as the output of the system, a silver-zinc electrochemical cell is recommended.

If it is desired to extract energy from the system more rapidly than from an electrochemical cell, and the use of a gasoline engine is not practical, then a flywheel system provides the best moduli. Weight and volume moduli for flywheels can be increased over that obtained for a cylindrical flywheel by shaping the flywheel as a uniform-stress disk with rim attached.

To store energy for longer periods of time than is practical in a flywheel, and to extract energy more rapidly than it can be extracted from an electrochemical cell when the use of a gasoline engine is not practical, a compressed-gas system is best. Spherical containers for compressed-gas systems are superior to cylindrical containers from the standpoint of weight and volume moduli.

Springs are inferior to the gasoline engine by a factor of 13,000 on basis of weight modulus and by a factor of 4000 on basis of volume modulus. Springs are inferior to a compressed-gas system by a factor of 450 based on the weight modulus and by a

(Continued on page 330)



STIFF SPECIFICATIONS

Yet a DIEHL motor met all requirements

The requirements of one of the largest milling machine manufacturers called for a close-coupled, special duty motor to raise and lower the knee and develop sufficient torque for heavy table loads in rapid traverse without stalling. Cool operation was imperative to avoid distortion of the machine table due to heat transfer. The motor was to be mounted directly on the gear case, therefore complete protection against oil leakage into the motor was essential. Motor size, compactness and appearance were important factors. DIEHL developed the special totally enclosed motor illustrated, which met all desired requirements. Cool operation was assured by the fan-cooled design of the motor, effectively preventing heat transfer. The flat-type construction saved considerable space and overhang, conforming well with machine contours. Positive and dependable machine operation was the end result.

This is another example of DIEHL accomplishment based on almost three-quarters of a century of experience in the design and manufacture of motors for industry. Utilize this experience in the solution of your motor problems. We'll work closely with you to provide the right motor — at the right time — at the right price.

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Electrical Division of
THE SINGER MANUFACTURING COMPANY
Findorne Plant, SOMERVILLE, N. J.

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factor of 100 based on the volume modulus.

Abstracted from "Work Capacities of Energy Storage Systems on Basis of Unit Weight and Unit Volume," by L. V. Kline, S. M. Marco and W. L. Starkey, The American Society of Mechanical Engineers Paper No. 57-SA-7, June 9-13, 1957.

Plastic Models

Plastic materials can be fabricated into models suited to various test conditions: hydrodynamic test models, models of blades, standard wind-tunnel models, and free-flight models have been built.

These models must be dimensionally stable, withstand applied loads, have high precision and best possible surface finish. In addition, models may need to satisfy special conditions, and often it should be possible to take them apart to install special instruments inside them.

Low-pressure polymerizable resins bonded to glass cloth provide economical construction of these models.

Construction of models differs in detail, but general method involves lining female molds with layers or batts of glass cloth impregnated with low-pressure resin. The "skin" or "shell" obtained may remain empty, it may be filled with a charged resin or a foam resin, it may house measuring or other devices, or may be occupied by a strong metal framework.

Abstracted from, "Fabrication of Models With The Aid of Plastic Materials," by G. Dixmier, translated from French, National Advisory Committee for Aeronautics Technical Note No. 33, March 1957.

"I was having a private discussion with the boss concerning his ancestry when suddenly he slipped up behind me and heard every word I said."

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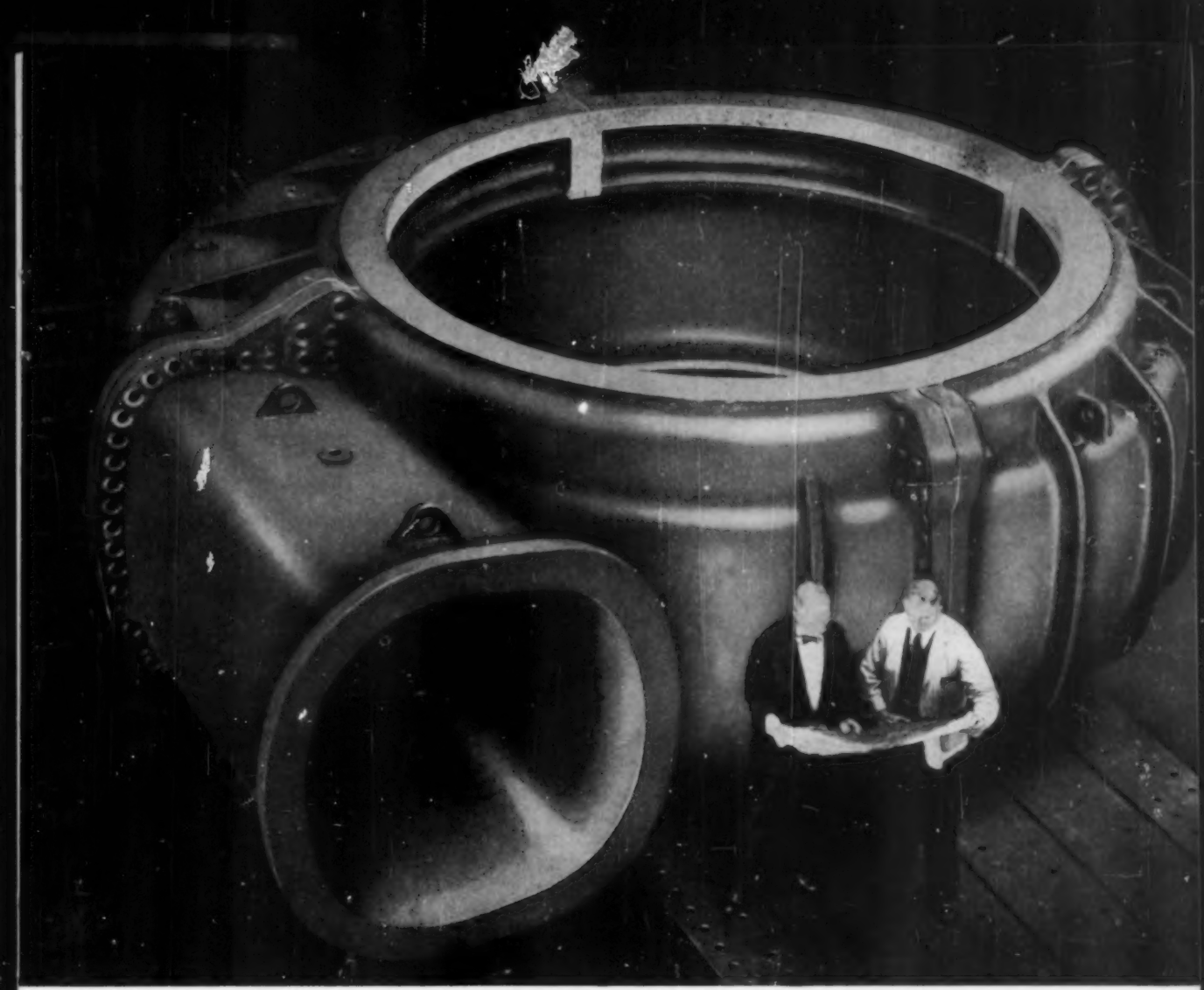


This huge casing for an 84" volute pump was cast in four sections in high strength (over 50,000 psi) Meehanite metal.

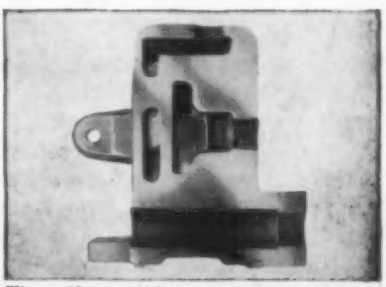
Pressure tight Meehanite castings are uniformly sound and possess high strength values

Meehanite metals provide designers, production men and engineers with a group of dependable materials that possess the superior combination of physical properties required by pressure tight castings used with water, oil, steam, gas and other substances.

The consistent uniformity of the structure of Meehanite metal throughout all casting sections insures excellent performance in service and offers positive freedom from leaks, porous zones and structural weakness.

In addition, Meehanite castings provide high strength values in the order of 55,000 lbs. psi and have a true modulus of elasticity which is important in computing bursting stress.

If you would like to know more about the advantages of Meehanite metal, write today for your free copy of bulletin #43 "Meehanite Castings for Pressure Tightness."



The uniform solidity and closeness of grain through all complex sections are revealed in this cross section of a Meehanite hydraulic valve unit.

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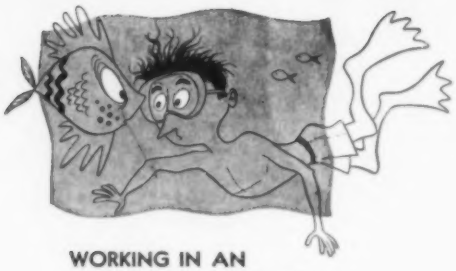
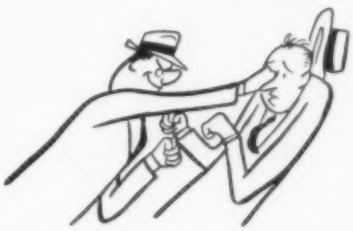
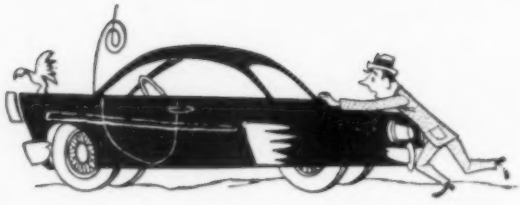


WORKING IN AN UNFAMILIAR ELEMENT?

BECOMING IRRITABLE AT ASSOCIATES?



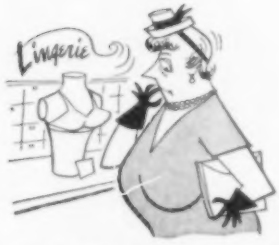
USING TRIAL-AND-ERROR METHODS?



NEW MODELS CREATING PERFORMANCE PROBLEMS?

NO PROBLEMS? (LUCKY FELLOW)

FIGHTING CORROSIVE CONDITIONS?



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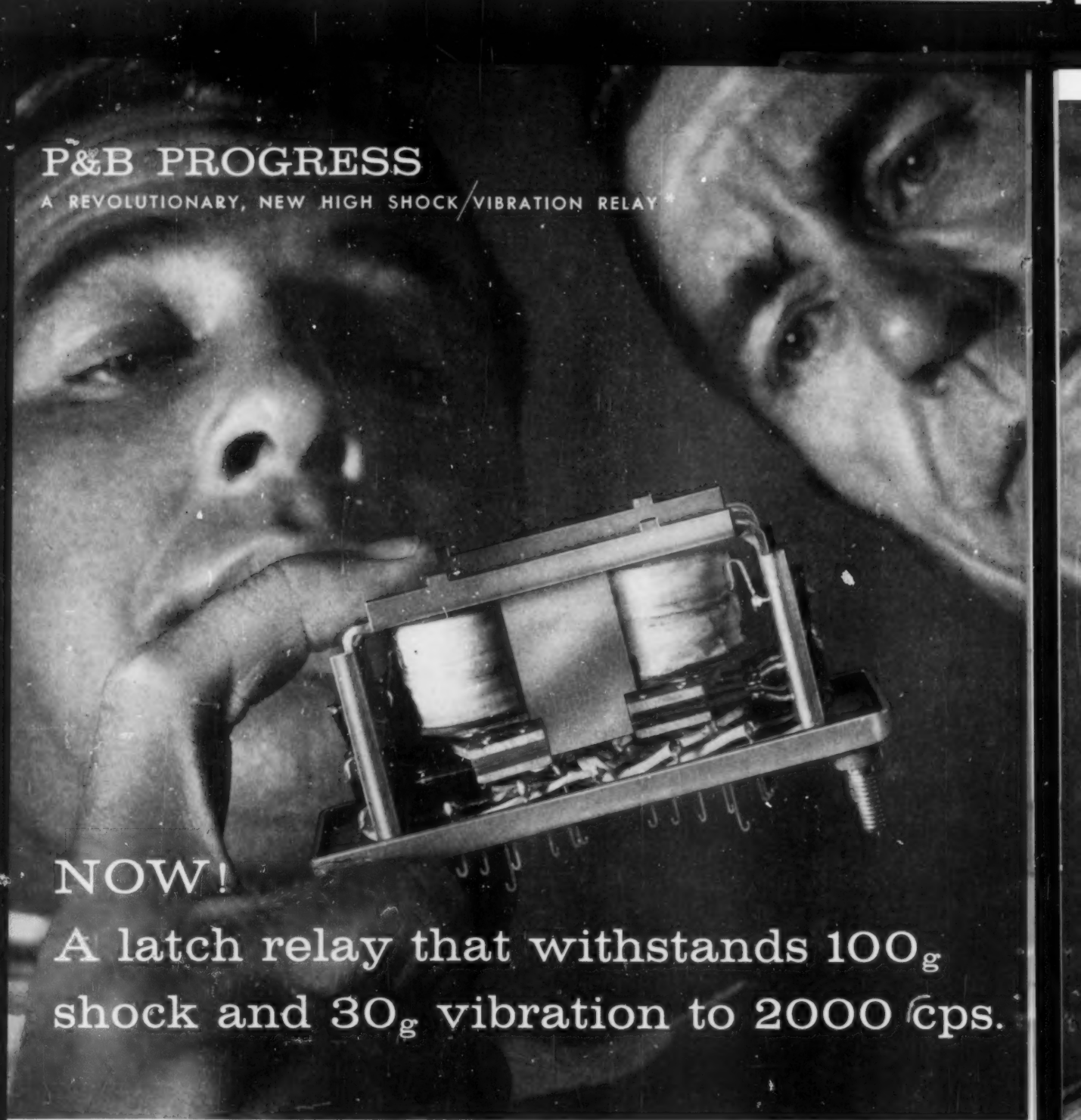
A REVOLUTIONARY, NEW HIGH SHOCK/VIBRATION RELAY



NOW!
A latch relay that withstands 100$_g$ shock and 30$_g$ vibration to 2000 cps.

*KG RELAY (Pat. Pending)

ONLY 2.0 WATTS AT NOMINAL VOLTAGE FOR 12 MILLISECONDS EFFECTS ARMATURE TRANSFER

NEW
POTTER & BRUMFIELD
KG SERIES RELAY

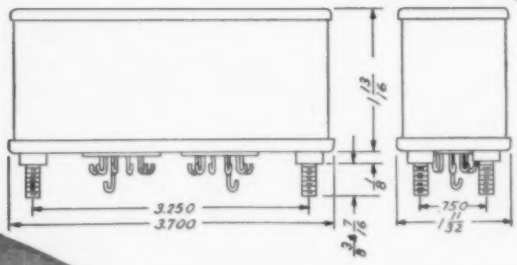
The new KG magnetic latch relay was designed by P&B engineers at the insistence of leading aircraft and missile manufacturers and their suppliers of control systems. A permanent magnet which locks the armature into position is the secret of the KG's dramatically high resistance to shock and vibration.

In addition to withstanding 30g vibration from 6 to 2000 cps, tests show the contacts will open for no more than 80 microseconds during 100g shock.

Armature transfer from one set of the 6PDT contacts to another can be made in approximately 12 milliseconds with only 2.0 watts at nominal voltage. The KG is rated for ambient temperatures from −65°C to +125°C.

The KG, together with other relays in the P&B "Star Series", has vastly increased the realm of relay reliability for critical applications demanding positive action of all components. Write or wire today for complete technical data.

POTTER & BRUMFIELD, INC., PRINCETON, INDIANA—SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY



STAR SERIES

KG RELAY

DESIGNATION: KG23D8H

GENERAL: Insulating Materials: Teflon, glass and ceramic.
Insulation Resistance: 100 megohms min.
Breakdown Voltage: 500 V. RMS.
Shock: 100g where contact openings less than 80 microseconds may be permitted.
Vibration: 30g 5 to 2000 cycles.
Ambient Temperature: −65°C to +125°C.
Weight: 13 ozs.
Pull-in-Speed: 12 MS using 310 ohm coil at 24 V. DC. (25°C).
Terminals: Two 11 pin multiple solder headers with hook ends for 3 #20/AWG wires.
Enclosures: Hermetically sealed only.
Dimensions: 1-11/32 x 3.700 x 1-13/16 (See drawing for width, etc.)
CONTACTS: Arrangements: 8 pole double throw.
Load: Dry circuit to 3 amps, 115 V. AC, resistive. 5 amps, 28 V. DC, resistive.
COIL: Power: 2.0 watts at Nominal Voltage.
Duty: Either coil may be left energized without damage to the relay.
Insulation: Teflon tape.
MOUNTINGS: Four 5/16 inch #8-32 studs on 3¼ x ¾ inch centers.

COIL DATA: (EACH COIL)

Voltage:	6 V. DC	12 V. DC	24 V. DC	48 V. DC	110 V. DC
Resistance: ±10% @ 25°C	14 ohms	55 ohms	310 ohms	835 ohms	5500 ohms

See What's New in P&B Progress at Booth 603, 604 WESCON, San Francisco, August 20-23

Potter & Brumfield, inc.
PRINCETON, INDIANA

Subsidiary of AMERICAN MACHINE & FOUNDRY COMPANY Manufacturing Divisions also in Franklin, Ky. and Laconia, N. H.

Mail the coupon below for further engineering data on P&B's new Star Series relays *plus* new compact catalog of standard type relays. If you need answers to a specific application problem, write in detail.

Potter & Brumfield, Inc., Princeton, Indiana
Attn: T. B. White, Brig. Gen. M.C. (Ret.)
Special Projects Engineer

Please send me complete data on the new Star Series relays, plus the new compact catalog of P&B standard relays.

Name_____
Company_____
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City_____ Zone_____ State_____

NEW BOOKS

1956 Supplement to ASTM Standards: Part 1—Ferrous Metals

6 x 9 in., 452 pp, paperbound. Published by American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. $3.25.

This 1956 supplement to Part 1 on ferrous metals contains the revised standards and the new and revised tentatives in these materials fields that have been accepted since the appearance of the 1955 Book of ASTM Standards. Eight of the 9 standards are replacements of existing standards, and one standard represents a tentative revised and adopted in 1956; similarly, of the 49 tentatives, 28 are replacements of existing tentatives, two represent standards revised and reverted to tentative, while 19 are published for the first time. Two standards and one tentative with minor revisions and 13 tentatives adopted as standard in 1956 without revision are listed in the contents but are not published in this supplement. Also listed in the contents are four emergency alternate provisions which have been withdrawn.

Sintered Titanium Powder

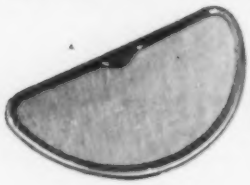
PB 121559, 8 x 10½ in., 34 pp, paperbound. Published by Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C. $1.25.

The development of titanium alloys by powder metallurgy which have the high temperature strength and stability of SAP, or sintered aluminum powder is reported. The sintered titanium powder was desired because of its high melting point. Procedures are described which produced a high-quality titanium hydride with outstanding room temperature tensile properties.

The base powder of an average particle size of 5 to 10 microns was made, compacted, dehydrated, sintered, and extruded into rod. Thorium

(Continued on page 336)

WIRE CLOTH PARTS



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Any Shape

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oxide was found to be stable in titanium when sintered at 1200 C, indicating that it can serve as the dispersed phase for dispersion hardening if a fine enough dispersion can be achieved.

The Presentation of Technical Information

REGINALD O. KAPP, 5 x 7½ *in.*, 147 *pp. Published by Macmillan Co.*, 60 5 Ave., New York 11, N. Y. $1.95.

This book is based on a series of lectures given by the author, an engineer, at University College, London, England, before an audience of engineering students. Some of the problems of preparing lectures and printed articles are discussed, including literary style, logic, maintenance of reader receptivity, choice of material, timing, understandability, sentence recasting.

Currents, Fields, and Particles

FRANCIS BITTER. 6 x 9¼ *in.*, 599 pp. *Published by Technology Press, Massachusetts Institute of Technology and John Wiley & Sons, Inc.*, 440 *Fourth Ave., New York* 16, N. Y. $8.50.

This is a new kind of text for a new kind of course in the physics curriculum. It provides all students of science and engineering with a solid introduction to certain abstract concepts, including energy, momentum, electric and magnetic fields, conservation laws, impedance and reactance. At the same time it offers an adequate scientific background for students entering non-scientific fields. Throughout, the author has attempted to illustrate the importance of quantitative thinking, and his emphasis is on factual analysis.

FBI Register

9¼ x 7½ *in.*, 1124 *pp. Published by Iliffe & Sons, Ltd., Dorset House, Stamford St., London S.E.* 1, *England. Approximately* $5.70.

This comprehensive guide to a substantial cross-section of British industry lists the products and services of over 7000 member firms under more than 5400 alphabetical headings. In

(Continued on page 338)

ACP RESEARCH AND DEVELOPMENT

... an ACP team to help solve metal-treating problems chemically

ACP is a leading supplier of chemicals for the treatment of metals. But more important still to its customers is its team of chemical and metallurgical engineers and technicians that tackle metal-treating problems, solving them economically and effectively with ACP chemical processes.

Typical of the work done by this united effort was the development of Granodraw SS.® This ACP product facilitates the cold forming of stainless steel rod and tubing. It also eliminates costly leading and de-leading operations in the drawing of wire. Another example of fine teamwork was the development of a chemical process greatly facilitating the drawing of zirconium tubing. This process, which effected major economies in the drawing operation, has brought us much closer to the ultimate use of atomic energy as a power source in industry.

The services of the ACP research and development team are yours for the asking. Call on us if you have a problem that requires this caliber of service in the chemical treatment of metals.

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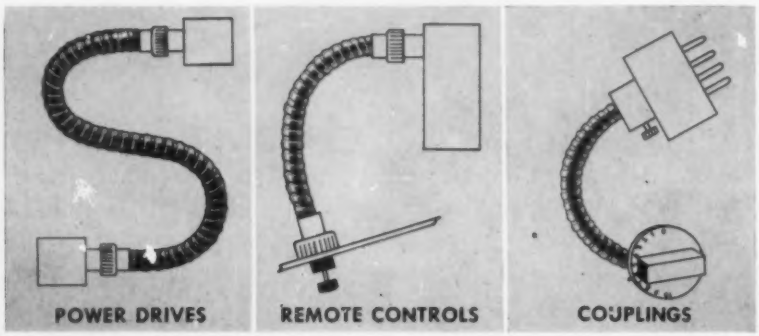

Lick the problems of designing smaller units . . . simplifying assembly . . . cutting production costs . . . with Robertshaw Flexible Shafting. Eliminates all the restrictions imposed by rigid shafting and connections in transmitting power or control between two points. No alignment problems. Connected members can be positioned for greatest efficiency and space-savings. Weight can be reduced substantially in many units.

Every inch of Robertshaw Flexible Shafting is "custom-made" to your exact needs for aircraft, automotive, appliance, machinery, radio, TV, electronic, portable tool and special applications. Complete engineering help on new or known uses.

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addition to the classified buyers' guide there are seven other sections in the register, giving addresses of companies and firms, and valuable information about trade associations, proprietary names, trademarks. A feature providing a useful reference for buyers not fully conversant with British product terms, is the French, German and Spanish glossaries. These give translations of every product term used in the main buyers' giude, each being numbered for easy reference between the English headings and their translations.

Introduction to Electrical Engineering, Third Edition

GEORGE V. MUELLER, *Prof. of Electrical Engineering, Purdue University.* 6¼x9¼ *in.*, 466 *pp. Published by McGraw-Hill Book Co.*, 330 W. 42*nd St.*, *N. Y.* 36, *N. Y.* $7.50.

This book presents the fundamental principles of electric and magnetic circuits and fields. The first eight chapters include necessary topics for a one-semester course; remaining chapters are suitable for a subsequent course or as reference material.

The book begins with a treatment of the laws and theorems applicable to d-c circuits. Resistivities of various materials and how these are affected by temperature changes, are considered. Nonlinear resistive elements are discussed, not only to show the applications of the elements, but also to

(Continued on page 340)

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Now the ride that can't be equalled for bottles, cans, containers and packages is the revolutionary Atlas Electrolized FLAT-VEYOR.

A new simplified design makes it stronger and easier to clean. Lower coefficient of friction and precision construction assures smoother operation . . . allow plates to "float" along with no drag, chatter or vibration. Water lubrication of chain is sufficient. These, plus the wider bearing design, reduce wear to less than one-half that of other corrosion resistant chain. Atlas Electrolized FLAT-VEYOR has a much higher tensile strength than stainless steel making possible greater loads and higher speeds without breakdowns.

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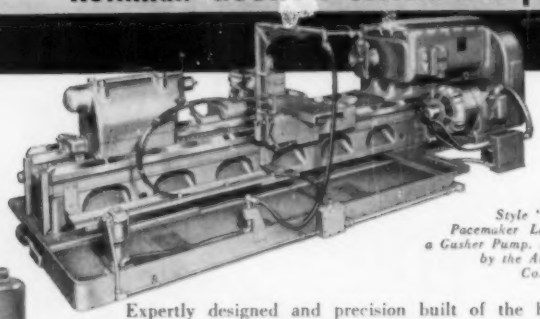
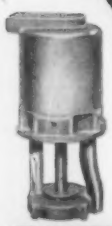


Illustrated is a 32" Style "1" De Luxe Model Pacemaker Lathe equipped with a Gusher Pump. Lathe manufactured by the American Tool Works Co., Cincinnati, Ohio.



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Expertly designed and precision built of the best materials, by the originators of this type pump. Gusher Pumps give you high quality at reasonable cost. The wide acceptance of Gusher Pumps by the metal cutting industry is your assurance of their efficiency in operation, low maintenance cost, and long trouble-free life.

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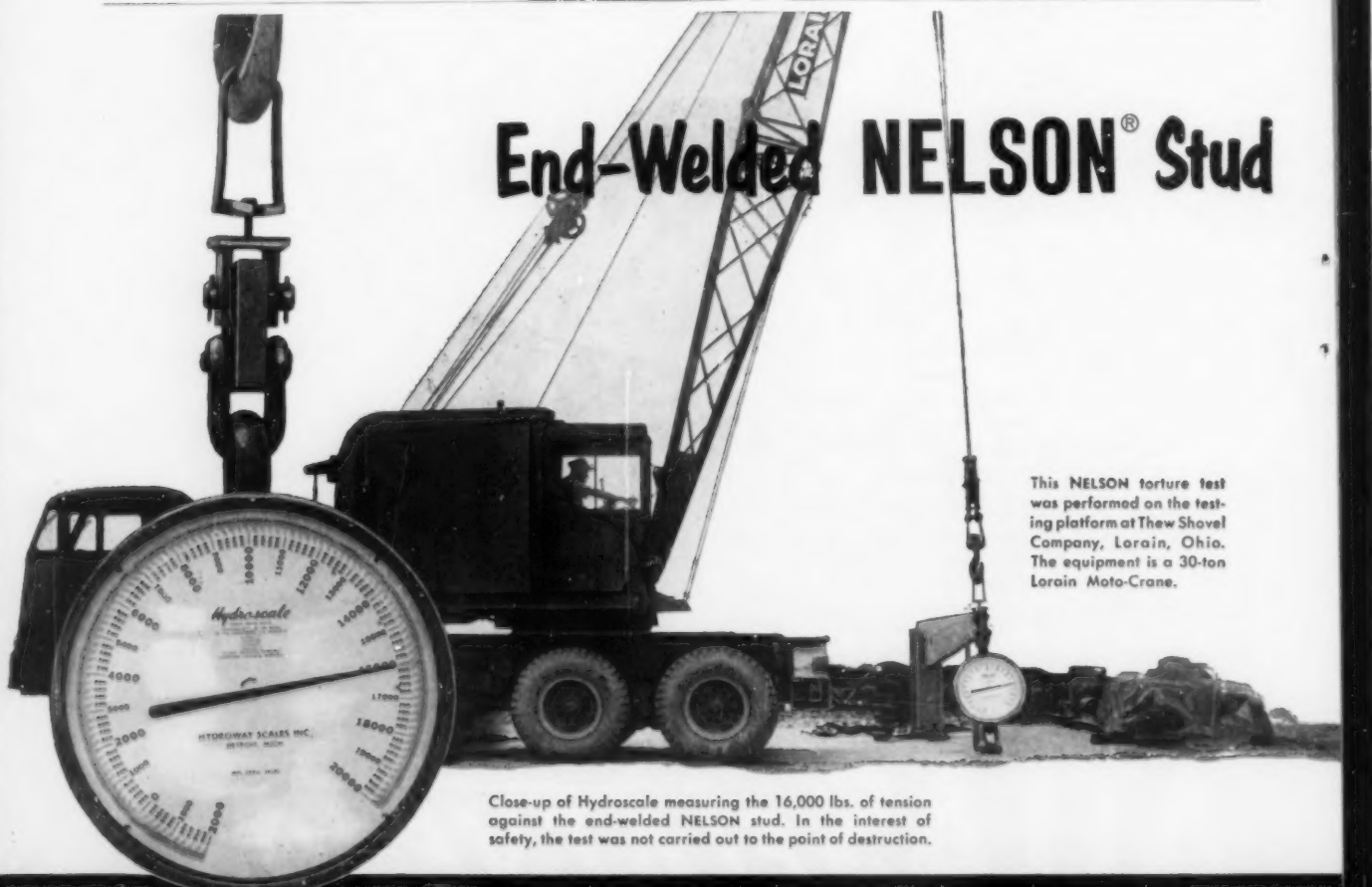
introduce analogous principles involved in electronic tubes and magnetic circuits. The concluding chapters consider transients in inductive and capacitive circuits and the principles of magnetic and electric fields.

In this third edition new material includes: tetrodes, pentodes, cathode-ray tubes, photoelectric tubes, transistors, magnetic amplifiers, the piezoelectric effect, and magnetostriction. Drawings have been revised to bring graphical symbols into agreement with specifications of the American Standards Association.

Satisfying the Salaried Employee

6 x 8½ *in., 63 pp., paperbound. Published by the National Association of Manufacturers, 2 East 48th Street, New York, N. Y.* $0.50.

Engineers are much concerned with job satisfaction in office and laboratory from the viewpoint of both management and employee. The National Association of Manufacturers has prepared this study covering the four im-



End-Welded NELSON® Stud

This NELSON torture test was performed on the testing platform at Thew Shovel Company, Lorain, Ohio. The equipment is a 30-ton Lorain Moto-Crane.

Close-up of Hydroscale measuring the 16,000 lbs. of tension against the end-welded NELSON stud. In the interest of safety, the test was not carried out to the point of destruction.

NELSON STUD WELDING . . .

portant areas of status and recognition, compensation, communication and supervision.

The booklet indicates to employes what workers want in their jobs and how it may be provided.

Electronic Measurements & Measuring Instruments

F. G. SPREADBURY, *Mgr., Electrical Investigation & Test Equipment Section of the Aircraft Div. (Rotax Ltd.) of J. Lucas & Co., Ltd., England,* 5¾ x 8¾ *in.,* 459 *pp. Published in the U. S. A. by Essential Books Inc., 16-00 Pollitt Drive, Fair Lawn, N. J.,* $8.

The science of electronic instrumentation is relatively new, but the number of different instruments and measuring techniques is already so numerous that it is impossible to give an account of all within a single volume. However, there are certain basic common types of instruments and measuring techniques. This book is mainly concerned with these instruments. Because the stability of electronic instruments depends largely

(Continued on page 343)

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Micro-Processed Compression Springs

For long spring life and reduced spring cost

I-S Beryllium Copper compression springs are hardened after forming to a tensile strength of 185,000 to 220,000 psi. The resultant springs offer you many advantages . . .

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- close tolerances
- long endurance life
- resistance of corrosion
- stability at elevated temperatures
- reduced inspection and assembly costs
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I-S Micro-Processed beryllium copper compression springs are the ideal springs for many applications . . . for pumps and valves — instruments and meters — relays — motor brushes — switches and many others.

Engineer's Assortment . . . 100 Micro-Processed beryllium copper helical compression springs—50 pairs—all different. Write for Bulletin No. 97-44—to help save time and money on development work.

For full information on I-S Micro-Processed Compression Springs — write for your copy of Catalog No. 7 . . . "Micro-Processed Springs of Beryllium Copper"

Instrument Specialties Co Inc.

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Telephone Little Falls 4-0280

Resists 8-Ton Load!

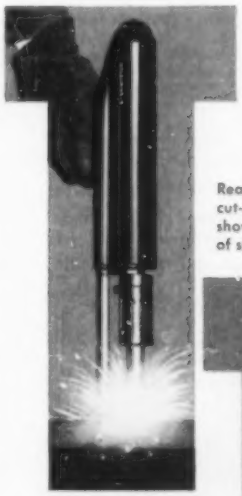
Close-up of stirrup used to complete the linkage between test stud and the crane cable hook. Photo was taken while stud was under full 16,000-lb. load. Bent stirrup indicates force of this grueling test.

• Nelson Engineers tested a ⅝" diameter standard headed stud to determine the strength of the weld.

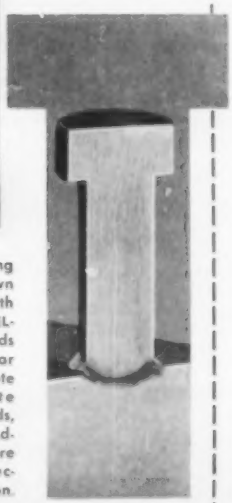
These photographs attest to the amazing tensile strength of a NELSON end-welded stud. Torsion and shear strength are equally amazing.

Holding power like this suggests that it pays to stop before drilling a hole and consider the NELWELD® method of fastening...the system that also saves time, eliminates flanges and bosses and makes "hole engineering" unnecessary.

The manual offered in the coupon goes into detail on design and applications, and recommended torque and tensile loadings of studs for normal applications.



Reason for strength... cut-a-way view of stud shows complete fusion of stud and base plate.



The headed stud being used in this test is shown being stud welded with the portable NS-9 NELWELD Gun. These studs are often used as shear connectors on concrete and steel composite bridges. Threaded studs, and a multitude of standard types and sizes are available for manufacturing and construction.

***NEW* NELWELD DESIGN MANUAL**

yours for the asking. Write your name, company, address in this space, and send to NELSON.

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Division of Gregory Industries, Inc., Lorain, Ohio

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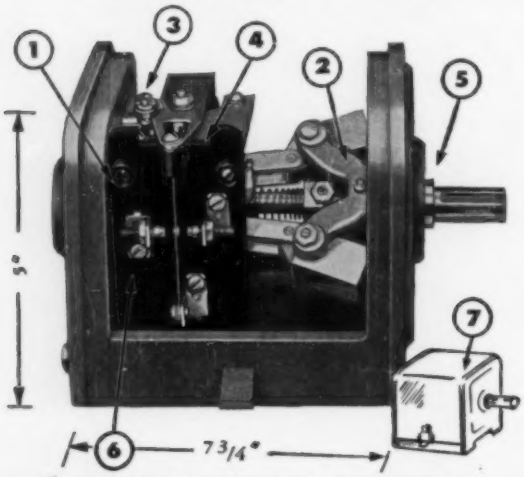

1. Available with any standard contact arrangement. Illustrated above is a two-circuit switch with normally open SPDT contacts.
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Thirty years of control application and manufacturing experience back this Euclid Electric & Manufacturing Centrifugal Switch which is finding wider and wider application on machine tools to increase production; on hazardous industrial machinery to increase safety; and for motion interlocking.

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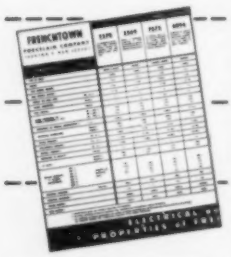

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on their components, considerable attention has been given to these and the problem of their stability. Tube characteristics relative to measurement are discussed together with the subject of stabilization by negative feedback. A number of basic-type instruments are fully described, many of these being of the author's design. Generally, the reader is assumed to possess a knowledge of basic electronics, but in some chapters principles are developed, particularly when they are pertinent to some piece of auxiliary apparatus.

Unfired Pressure Vessel Code Simplified

ROBERT CHUSE. 30 pp. *Published by Robert Chuse, P. O. Box 91, Leonia, N. J.* $6.50.

This is an analysis of the 1956 ASME code. In its 30 pages are simplified charts for internal and external pressure, shell thickness, flanged and dished head thickness, flat head thickness, flat cover plate thickness, and openings and reinforcements. Also included in the book is a section on welding procedure which is a guide to solving welding procedure problems.

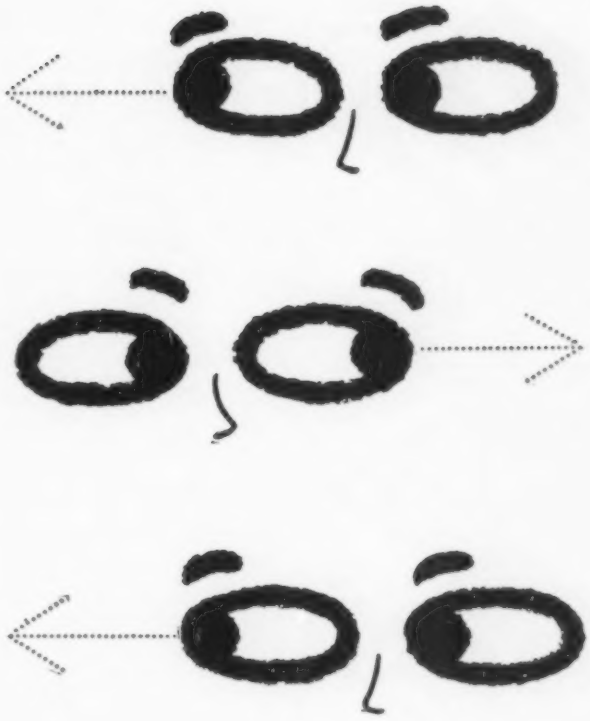
Magnetic-Amplifier Circuits—Second Edition

WILLIAM A. GEYGER, *Magnetics Div., U. S. Naval Ordnance Laboratory, White Oak, Silver Spring, Maryland,* 6½ x 9¼ *in.*, 394 *pp. Published by McGraw-Hill Book Co., Inc.*, 330 W. 42 St., *New York* 36, *N. Y.* $7.

Presents a practical treatment of the fundamental principles, characteristics, and applications of magnetic-amplifier circuits. The book develops logically the various kinds of basic and more complex circuit arrangements, emphasizing experimentally observed phenomena and avoiding extended mathematical con- Primarily descriptive and graphical siderations and cumbersome proofs. methods are used to give a qualitative and quantitative interpretation of the essential facts.

This edition has been enlarged to cover advances in the field, including development of stable high-speed

(Continued on page 344)



Alternating stresses bear watching!

Back and forth . . . up and down . . . in and out . . . if those stresses keep changing, the life of a metal part is a hard one . . . and often a short one. Stress reversals can cause "fatigue" failure at stresses far below the expected strength of the metal. One of the outstanding properties of phosphor bronze is its high resistance to fatigue failure. It is widely used for electrical switch parts, relay contact springs, bellows, rotating shafts and other moving or vibrating parts.

For detailed information on phosphor bronze, write to Riverside-Alloy Metal Division, H. K. Porter Company, Inc., Riverside, N. J.

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Need Holes in Metal Sheets?

Several considerations must usually be observed. The design should be attractive in appearance, with adequate open area, while still, for some purposes, affording suitable concealment of what lies behind or underneath.

WHEREVER perforated metal is required, and it has thousands of applications today, you'll do well to contact DIAMOND. Forty years of widely diversified experience and hundreds of modern tool arrangements, enable us to give unsurpassed quality and delivery at competitive prices.

Catalog 39 shows many interesting applications and contains complete illustrated working data. No charge or obligation, but kindly state business connection.

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WYOMING — WILKES-BARRE AREA — PENNA.

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Los Angeles Area

magnetic amplifiers, and the application of magnetic amplifiers in high-performance closed-loop servo systems. In addition, the treatment of the transient response of magnetic amplifiers has been expanded.

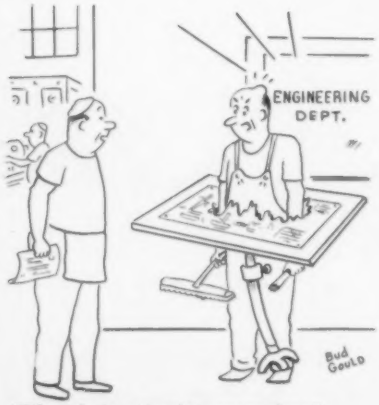
At the end of each chapter is a list of both European and American patents and associated technical papers.

Aircraft Hydraulic Design

GEORGE R. KELLER, *Group Leader, Flight Control Engineering Dept., Autonetics, 6 x 9½ in., 130 pp. Published by The Industrial Publishing Corporation, 812 Huron Road, Cleveland 15, Ohio, $4.50.*

Hydraulic systems designed for high performance aircraft continue to be the pace-setters of system and component design. Faster response speeds without loss of position and velocity control impose difficult performance specifications.

The first section of this book develops basic hydraulic theory; the properties of hydraulic fluids, fluid statics and dynamics, flow through orifices and and pipes. Later chapters cover the design of actuators, valves, power packs, transmission lines, seals. A single chapter introduces the servo concept and describes some of the analytical tools used to design and test feedback systems of this kind. The book closes with a discussion of the problems of high temperatures and their effect on the operations of individual components and on the system as a whole.



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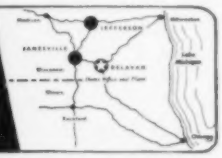

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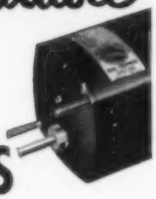

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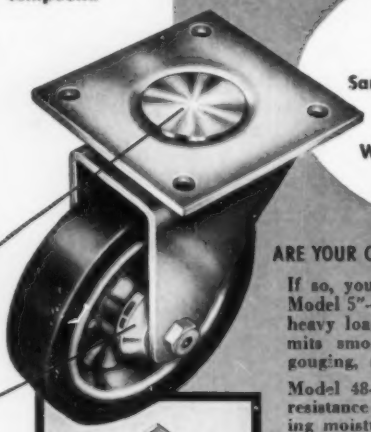

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OUR READERS SAY . . . . . :

Letters should be addressed to the Editor, *Product Engineering*, 330 W. 42 St., New York 36, N. Y.

Inventors and National Security

To the Editor:

The issues at stake in Dr. Halpern's case (June p 199) are, I believe, much larger than a mere matter of an individual being deprived of compensation due him. The military bodies of the U. S. are, to an increasing degree, usurping the functions of the executive and judicial bodies in their relationship with civilians.

The military holds the attitude that their business relationships are governed by military law and not subject to review by civil courts. Application of security classifications to withhold information and to limit the effectiveness of normal judicial procedure is, I suspect, fairly common.

There is something basically wrong with the military services of a democracy that lose sight of the fact that they are, and must always be, subordinate to the rights of the individual. The excuse of security to abridge these rights is a contradiction of basic logic. Security exists only as long as each individual has the rights outlined in our constitution.

Dr. Halpern's case happens to be an excellent starting point for a complete re-examination of our civilian-military relationships. Our military leaders seem to have forgotten their basic responsibility—to uphold the spirit and letter of the constitution against attack from any source.

—Theodore J. Quinn
Cresskill, N. J.

Justice Postponed

To the Editor:

Of course, no one will seriously dispute that postponement for any material length of time dilutes the value of the ultimate decision, which diminishes as time lengthens.

The remedy to correct the obvious

(Continued on page 349)

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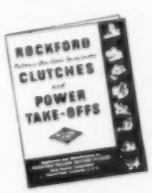

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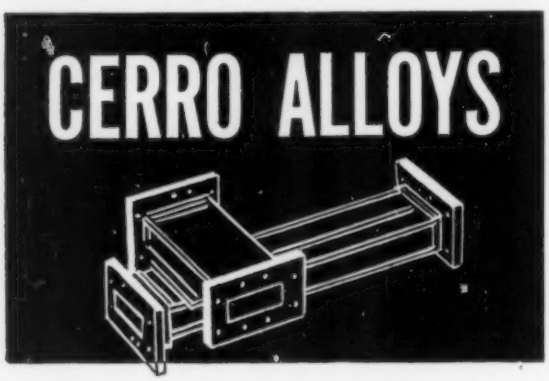

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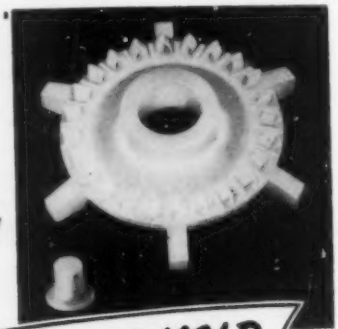

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evil, suggested by your news story (June, p. 199), namely, decision by committee, is not the solution. This merely substitutes one judicial body for another without setting up adequate criteria on which to act.

It should be borne in mind that the purpose of the patent law is to encourage inventions by granting a limited monopoly over the thing invented to the inventor. Where, however, there can be but one user, the feature of monopoly is of doubtful value. Here, it seems, only the United States government could use the idea protected by the patent, and no one else. Since, in this case, and in all others involving secret matters, the patent itself has little value, the inventor is better off negotiating with the government at arm's length prior to patent application, and if successful the novelty can then be revealed in detail.

Legislation setting forth objective criteria for determining value might be enacted and a duty imposed on the Secretary of Defense to evaluate the invention based on such criteria. Some such criteria might be novelty, importance to the government, total costs and profits to the manufacturer, experimental costs, time consumed, and doubtless many others. This leaves the decisions to those already familiar with the "secret" based on measurable incidents and it should be presumed that those specifically charged with making the evaluation will do their duty and act fairly.

—Lee Hazen, Esq.
Attorney at Law

Attrition Rate at Rutgers

To the Editor:

In response to your article on "The Attrition Rate of Engineering Students," (May issue) I have found this material very interesting. Your comment that Rutgers has "not had too many takers" for the optional five-year program is literally correct since approximately ⅛ of the students who were admitted last September chose this plan. However, we have felt very much encouraged by the fact that as many as 50 freshmen should voluntarily choose an additional year of education. —Elmer C. Easton
Dean, College of Engineering
Rutgers University

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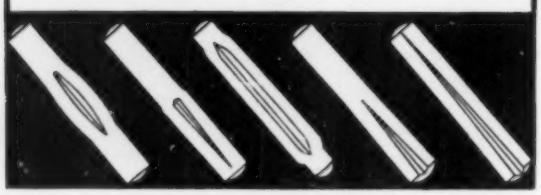

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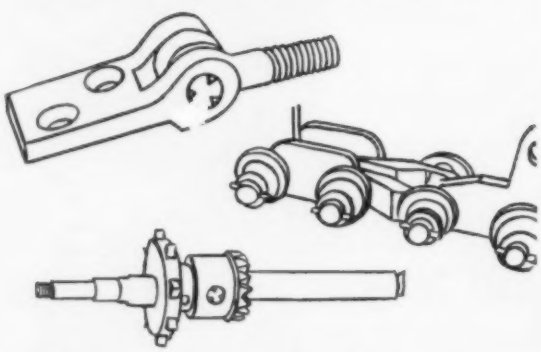

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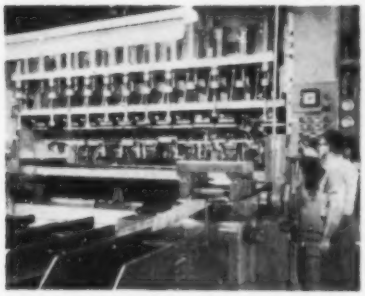

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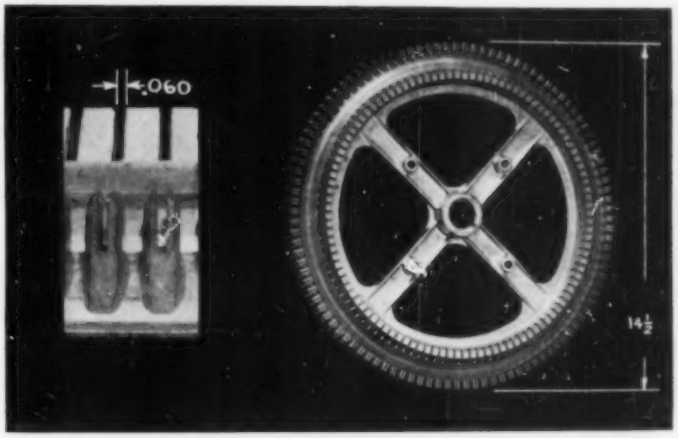
West Coast Atomic Laboratory

The General Electric Co has dedicated its new Vallecitos Atomic Laboratory, Pleasanton, Calif. In pointing out the significance of the laboratory, Francis K. McCune, a company vice president, said that Vallecitos staff members will solve many of the problems in fabrication of fuel and reducing high initial costs of

(Continued on page 353)



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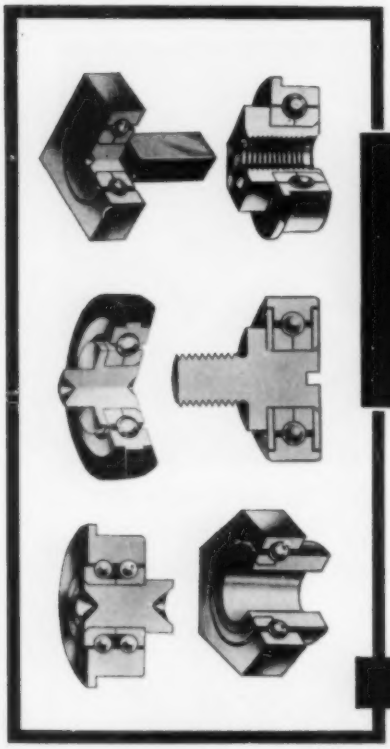

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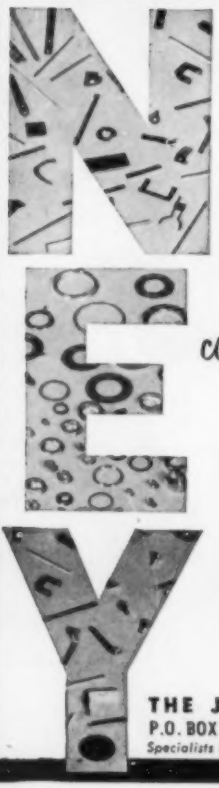

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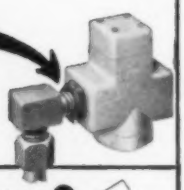

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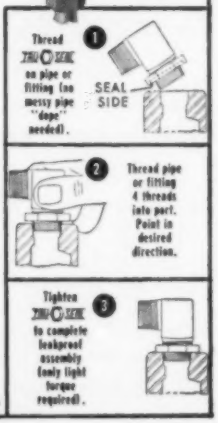
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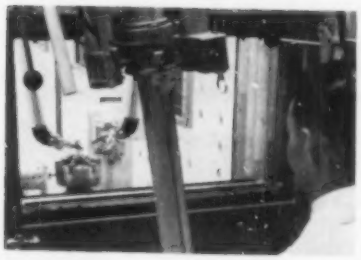
Thread pipe or fitting 4 threads into part. Point in desired direction.
3
Tighten TRU-O-SEAL to complete leakproof assembly (only light torque required).



MECHANICAL "HANDS" place an irradiation capsule in chuck of remotely operated lathe.

atomic power stations that prevent atomic power from becoming competitive with conventional power.

The multimillion dollar laboratory is made up of three main components: a radioactive materials laboratory equipped to carry out studies of materials which have undergone nuclear irradiation. Studies there will aid in selection of improved materials for reactors and improved reactor fuels.

An experimental physics laboratory which will house a critical assembly for mocking up various types of reactor cores, a nuclear test reactor for measurement of nuclear properties and for calibrations, a core assembly room and other laboratory space.

A developmental boiling water reactor for testing new designs and features of reactors developed by the company.

Soon to be added to the laboratory will be the fourth major nuclear facility, a $4 million materials testing reactor. Construction is expected to start soon, with the reactor in operation in late 1958. It will be one of the first large test reactors to be financed and constructed by private industry.

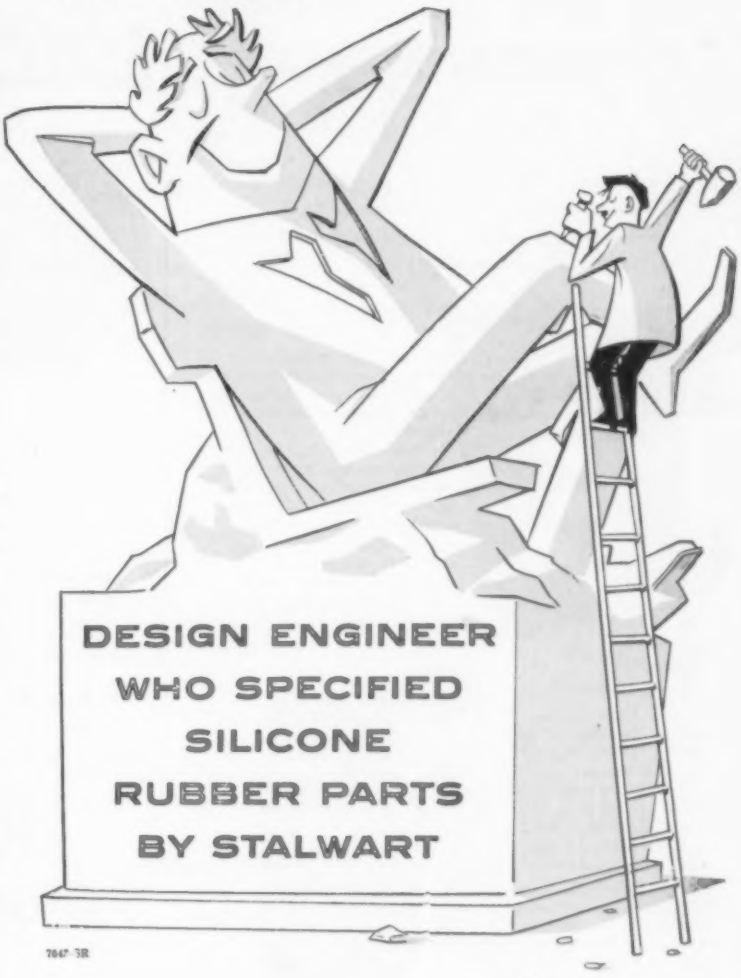
The Vallecitos laboratory is part of the company's Atomic Power Equipment Dept., at San Jose, Calif., which centralizes the company's design, development, manufacturing and marketing of peacetime atomic products.

Laboratory for Testing Adhesives

A new laboratory has been constructed by Raybestos-Manhattan, Inc., at its plant in Stratford, Conn., for the development and testing of adhesives, coatings, and sealers made by its Adhesives Dept. The new lab-

(Continued on page 355)

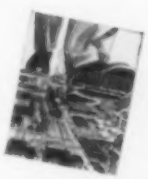
MEET A HERO:



Design engineers can rest on their laurels when they insist on the advantages of Silicone rubber parts by Stalwart. Here are just a few of the many outstanding features of Stalwart Silicones:

1. **Stalwart Silicone parts can withstand temperature extremes from −130° to +600° F. without losing physical, chemical or dielectric qualities.**
2. **Silicone parts provide excellent resistance to many chemicals, oils and moisture.**
3. **For special applications, Silicones can be combined with nylon, dacron, orlon, asbestos, fiberglass, wool or cotton.**
4. **Silicone parts can be molded, extruded and lathe-cut automatically or by hand.**

Stalwart engineers are prepared to work with you to produce compounds and shapes to meet your specific requirements. Why not write or call us today.



Write for your copy of Bulletin 56-SR-3

STALWART RUBBER COMPANY

MANUFACTURING PLANTS IN BEDFORD, OHIO AND JASPER, GEORGIA: MAIN OFFICES AT 166 NORTHFIELD RD., BEDFORD, OHIO

Some SANDSTEEL Pointers On Selecting SPRINGS
For Your Product

Here are the two basic types of Sandsteel springs along with a general indication of the type of service they are suited for.

SPIRAL
For Ordinary Applications

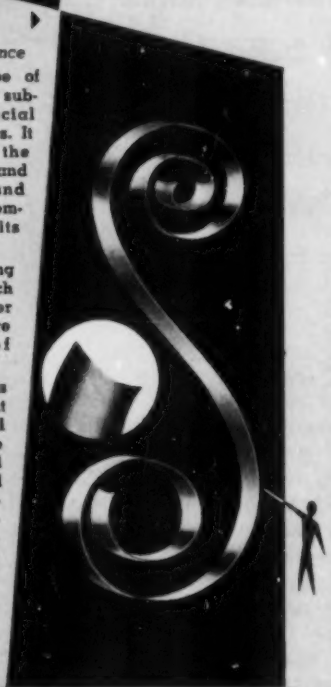
This is the common clock spring or hairspring, which can be operated within a spring drum or anchored to a post so that it will function without support around its circumference. This is the type of spring used in recoil starters for gasoline engines, guard return springs for portable electric saws, wind-up springs for toys or tension devices where constant torque is not critical.

SANDSTEEL CROSSCURVED
For Super-Performance

In this unique type of spring, the steel is subjected to our special crosscurving process. It is curved across the width of the strip and the spring is wound against both its tempered spiral and its convex curvature.

This gives the spring a dual tension—which provides dual power and a longer, more even release of energy.

This type of spring is used where constant power is required through one or more revolutions. Typical applications would be for timing instruments, carriage return springs for typewriters and office machines, power springs for motion picture cameras and other applications requiring precision power springs.



When spring performance is important, specify Sandsteel springs. Write for free literature and case history files.

SANDVIK STEEL, INC.
SANDSTEEL SPRING DIVISION
Fair Lawn, New Jersey
Tel. Fair Lawn 4-6200
In New York: ALgonquin 5-2200

SS-134

Standard or High Capacity

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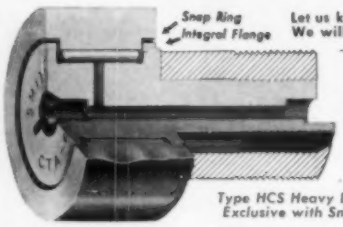
is Made to Fit Your Need



Let us know your maximum load. We will advise proper stud size.

TYPE CTA COMPLETELY INTERCHANGEABLE WITH STANDARD BEARINGS

This remarkable follower is in a class by itself. It has a snap ring that holds the roller in place—IT CANNOT SLIP OUT. The outer race with heavy wall, and full compliment of rollers, will resist excessive, intermittent shock loads far beyond the capacity of ordinary bushings or sleeve type bearings.

The stud diameter can be made up to 100% greater in relation to the size of the roller.

Two steel, serrated grease-retaining plugs, which cannot be displaced with a grease gun, are supplied at no extra cost.

The price of Standard or Heavy Duty is the same.

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No Lubricant "Teflon" Plug Valves
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pressure balanced for easy turning

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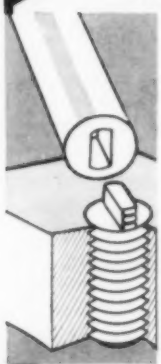
GREATER HOLDING POWER at LESS COST with Setko SLABBED HEAD Set Screws!



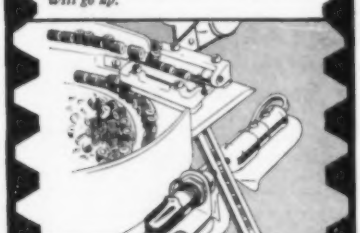
- *Will Take 50% more torque*, unique design resists damage.
- *Costs Less* than hexagon or fluted socket set screws.
- *Fully threaded.*
- *NU-CUP®* or standard points* available.
- *Can be Automated* with Setko's Hopper Feeding method.

*U. S. Pat. 2,778,265

Setko Slabbed Head Set Screws are real money savers. They cost less than comparable hexagon or fluted socket set screws, yet they take greater tightening pressures . . . Up to 50% more torque without damaging.

Holding power can be even further increased when furnished with Setko's own NU-CUP, the patented holding cup point that has a 42% sharper cutting angle. Cuts are deeper and in a full circle . . . With the extra pressure that can be exerted on the Slabbed Head Set Screw, NU-CUP really digs in tight.

Whether you drive them manually or with power . . . And whether your needs are large or small, *your costs will go down and holding power will go up.*



You Cut Costs Way Down When You Automate

Experience has proven that insertion rates of Slabbed Head Set Screws can be greatly increased when Automated by Setko's revolutionary Hopper Feeding System.

WRITE TODAY for full information . . . and ask for Catalog 21 which describes the complete Setko line of Set Screws.

Set Screw & Mfg. Co.

Pat. No 2,638,945
Other Patents Pending

153 Main Street, Bartlett, Illinois

157

oratory equipment includes tensile machines for shear and peel tests, ovens for testing up to 600 F, pilot mixers, salt spray testing cabinets and humidity testing area. The latter permits testing the drying time and other properties of adhesives under a great variety of climatic combinations.

Plant Expansion To Increase Fastener Production

To increase production of precision fasteners, Standard Pressed Steel Co. will build a 55,000 sq ft addition to their Jenkintown, Pa. plant. The $750,000 building will also enable the company to enlarge its research and development laboratories. Though the new plant addition will not immediately house either fastener producing or research equipment, it will, when completed in 1958, make room for an increase in these facilities in other areas of the plant.

Laboratory to Operate On Contract Basis

A new laboratory which offers research and development services on a contract basis has been established in Madison, Wis., by Trionics Corp. The services of the laboratory are available to both industrial and government sponsors. It will employ more than 30 persons and plans call for an increase in staff to more than 70. The research program of the laboratory is

(Continued on page 357)

"But why did you kick a desk?"

When to specify

VULCAN ELECTRIC CARTRIDGE HEATERS

1. When application is for: Complete insertion into machine parts, dies, platens, molds, presses, die blocks of embossing machines, packaging machines, etc.

2. When specifications call for: Length—1″ to 25″ (or longer); diameter—¼″ to 1 19/64″ (or greater); wattage — 10 to 3200 (or higher); voltage — standard 115 or 230, special 6 to 440; sheath — brass, steel, nickel or high temperature alloys; standard or special lead wires or terminals.

3. When you have "hot" problems: Vulcan Engineers are ready to provide special heating units — engineered to your needs.

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to resist stress, wear and vibration

They increase product durability at low initial cost

Simple one piece design — no inserts — no outside devices. Nothing complicated — the Gripco locking action is within the nut itself, yet you get low initial cost and low application cost with increased customer satisfaction. Speed production and lower manufacturing costs on your products now.

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all with or without the famous Gripco positive locking feature. Also Standard Semi-Finish Nuts.

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LOCALITE fostoria for Light ON the Job

primarily designed to develop new and improved materials to meet the requirements of specific technological advances. Special fields in which the laboratory will be active include high and low temperature resistant materials, magnetic materials, ceramics, coatings and surface treatments, plastics, electronic component materials, high strength-low weight materials, corrosion inhibition and metallurgy.

The facilities of the laboratory are located in a one-level building which provides more than 16,000 sq ft of floor sace. Separate departments are maintained for metallurgy and ceramics, microwave research and theoretical physics, applied physics, electronics and instrumentation and engineering (pilot stage operations). Each department is equipped with standard and specialized equipment for investigation of problems related to materials development and improvement.

Technical Center For Heating Equipment

A $1¼ million technical design center was opened in La Crosse, Wisconsin, by the Trane Co., manufacturer of air conditioning and heating equipment. The single story, 65,000 sq ft building will enable the company to continue product research in the field of heat exchange.

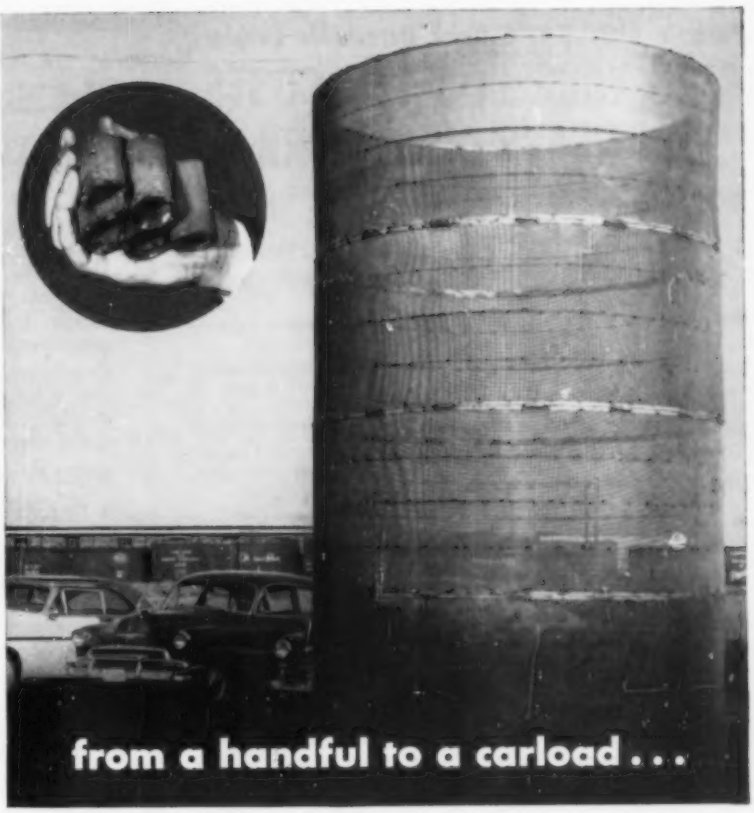
Wire Division Modernized

A $2½ million program of expansion and modernization is under way at the Electrical Wire Div., John A. Roebling's Sons Corp., Trenton, N. J. The major objectives of the program are improved product quality, more advanced scheduling and handling methods, and the introduction of new products.

Roller Chain Company Expands

Acme Chain Corp., Holyoke, Mass., have commenced operations in their new 100,000 sq. ft., single story building. The company produces roller chains, leaf chains, and special attachments for the conveying and elevating of materials.

(Continued on page 359)



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From giant retaining screens for catalysts or filter media to small strainer assemblies for Diesel engines, fabrication of wire cloth parts to a wide variety of demands is a daily operation at Cambridge. Whatever your needs . . . filter leaves, strainers, sizing screens, retaining screens . . . you can rely on Cambridge for quality and prompt service. We'll work from your prints or draw up prints for your approval.

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"Dogs" instead of "balls" lock steel against steel . . . hold tighter, without leakage . . . positioned by "floating steel carrier" which absorbs vibration of pulsating air. Chrome sleeve is of stress-proof, heat treated steel to withstand roughest treatment. The Fostermatic is right for 90% of all uses.

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Graduate mechanical engineers are needed at Procter & Gamble's modern laboratories just outside Cincinnati to develop new packaging machinery. Here you will find:

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- *Opportunity to advance in a growing activity.*
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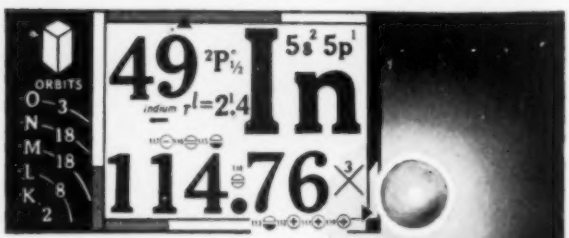

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Bar Mill Begins Production

The new cold finished bar mill of Jones & Laughlin Steel Corp., has begun production at the company's Willimantic, Conn. plant. Hot rolled bars will be rolled at company mills in Pittsburgh and shipped to Connecticut for cold drawing and processing into cold finished products. In the Willimatic process, J&L will be one of the first American steel companies to use Schumag continuous cold drawing machines. Coils of hot rolled steel are fed into the machines, which draw, straighten, polish and cut to length in one continuous operation. The new mill will initially employ about 60 to 70 persons.

Two New Plants for Spring Company

Associated Spring Corp., Bristol, Conn., will establish two new precision mechanical spring manufacturing plants—one in Montreal and the other in Puerto Rico. The new branch plant in Montreal will be operated by The Wallace Barnes Co., Ltd., the corporation's wholly-owned Canadian subsidiary. The Canadian company is acquiring a site in the Pointe Claire industrial district, and will break ground there this month for a new building to house the facility. Manufacturing operations are scheduled to begin late this fall, with initial employment expected to rise from about a dozen to approximately 30 people by the first of the year.

The new plant in Puerto Rico will be the first precision spring manufacturing plant to be established in the Caribbean area. It will be operated by a new wholly-owned subsidiary to be organized for this purpose. The plant will be in operation by January.

New Divisions

Beckman Instruments, Inc., announced the establishment of its Process Instruments Div., with headquarters in Fullerton, Calif. The new division will also maintain an eastern manufacturing and engineering facility in Ronceverte, W. Va.

A Plastics Machinery Division has

(Continued on page 361)

WITH COMPACT

I-R COMPRESSORS

...for DEPENDABLE, long-life EFFICIENCY

When important production equipment depends on air for operation, you'll breathe easier knowing that the best compressors are there with the air—whenever needed. Ingersoll-Rand Type 30 Compressors are designed and built to exacting standards that insure efficient and continuous service.

Rugged construction and low maintenance have characterized I-R Compressors for years—and for years Ingersoll-Rand has set the standard for economical compressor performance in every type of duty.

For your air-operated equipment, specify Ingersoll-Rand Type 30 Compressors. Choose *exactly* the unit you need from I-R's complete line of packaged air-cooled units from ½ through 20 horsepower. Write today for descriptive literature showing bare, baseplate mounted or complete receiver mounted units.

Packaged air-cooled compressors—½ through 20 horsepower. Other compressors to 6000 horsepower.

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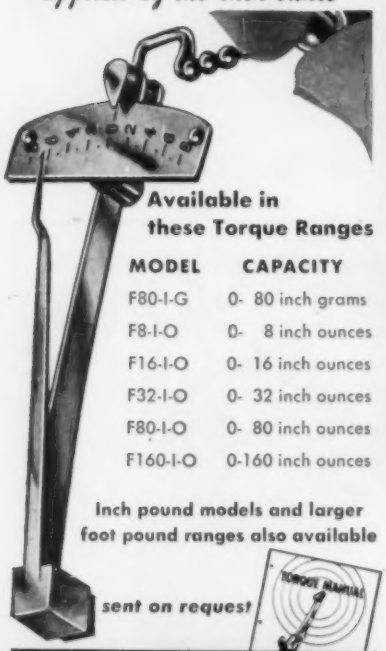
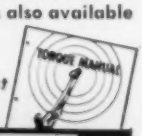


Available in these Torque Ranges

MODEL	CAPACITY
F80-I-G	0- 80 inch grams
F8-I-O	0- 8 inch ounces
F16-I-O	0- 16 inch ounces
F32-I-O	0- 32 inch ounces
F80-I-O	0- 80 inch ounces
F160-I-O	0-160 inch ounces

Inch pound models and larger foot pound ranges also available

sent on request



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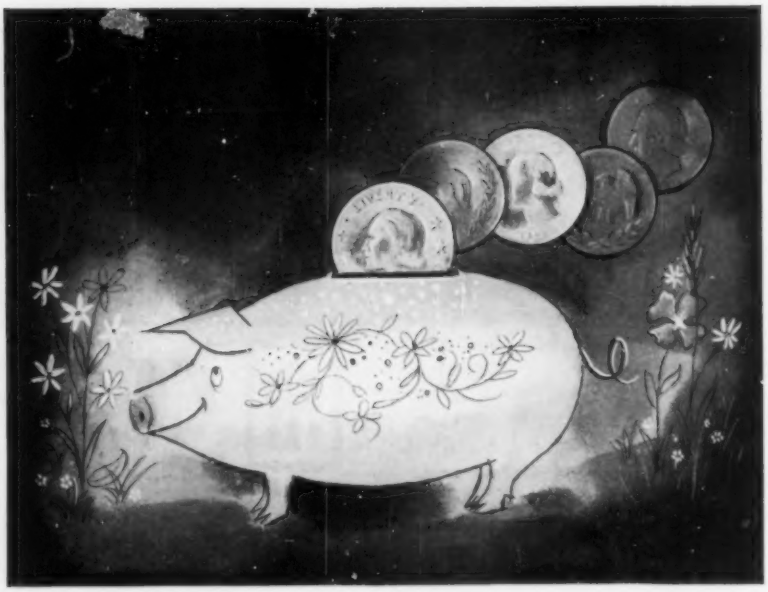

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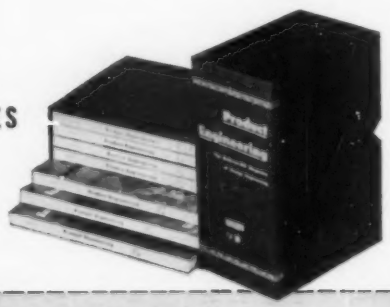

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STRATAFLO PRODUCTS, INC.

FORT WAYNE 1, INDIANA

been formed by National Automatic Tool, Inc. The new division will produce plastics injection molding machines.

Magnetic Research Corp., Hawthorne, Calif., has created a new department for the development and manufacture of complete magnetic servo systems. Equipment is currently being designed and produced for fuel rate and temperature control in military applications.

New Process Gear Corp., Syracuse, N. Y., has become the New Process Gear Division of Chrysler Corp.

Raybestos-Manhattan, Inc., has established a Pacific Coast Division in Paramount, Calif., to manufacture Teflon and Raylon products.

Consolidated Electrodynamics Corp. has formed a Datatape Division to design and manufacture a standard instrumentation line of magnetic-tape recording and reproducing equipment.

Name Changes

Consolidated Electrodynamics Corp., Pasadena, Calif., has changed the name of its Electronic Industries Division to the Alectra Division.

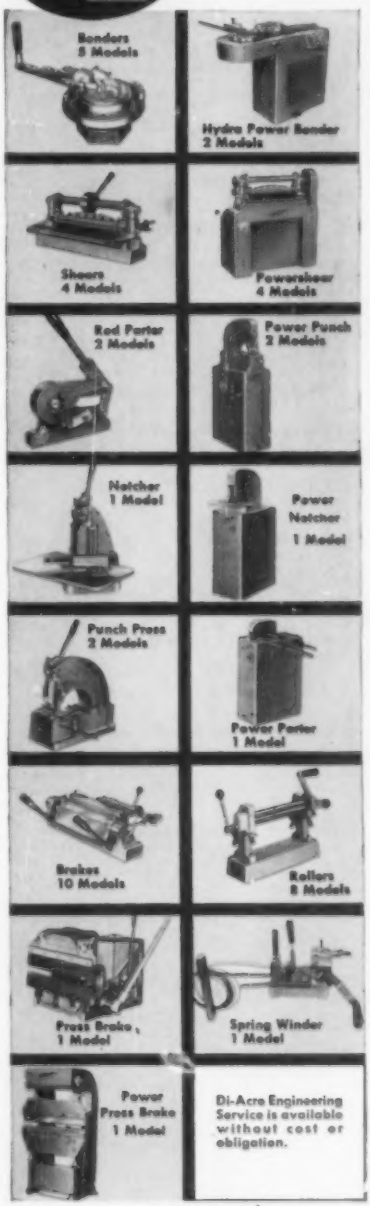
Greer Industries, Inc., Jamaica, N. Y., has changed its name to Disogrin Industries, Inc. The company has also terminated its affiliations with Greer Hydraulics, Inc.

Aluminum Good Mfg. Co., Manitowoc, Wis., will change its name to Mirro Aluminum Co., on the first of next year.

"You're hired."

Speed FORMING and FABRICATING

di-acro PRECISION METALWORKING MACHINES for die-less duplicating


Benders 5 Models
Hydra Power Bender 2 Models
Shears 4 Models
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Notcher 1 Model
Power Notcher 1 Model
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Power Parter 1 Model
Brakes 10 Models
Rollers 8 Models
Press Brake 1 Model
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Di-Acro Engineering Service is available without cost or obligation.

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333 8th Ave. • Lake City, Minn.

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CHICAGO: 520 N. Michigan Ave. (11)
SAN FRANCISCO: 68 Post St. (4)

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Position with metal fabricating, or metal processing company. Primary interest lies in production, manufacturing, and cost departments. MBA degree, 1954, Harvard Business School. BS degree, Industrial Engineering, Yale University. Present.-Assistant Navy Exchange Officer. To be released December 1957. Married, one child. PW-5538, Product Engineering.

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Fall '57

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Write Today.

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TOP MANUFACTURING EXECUTIVE
$30-$35,000—plus bonus

Require Graduate M.E., age to about 40; experience at executive level in heavy metal-working plants; knowledge of metals, steels and alloys.

Must have keen ability in developing and improving methods and equipment.

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Creative assignments in research and development are offered in Sylvania's Electronic Defense Laboratory in the San Francisco Bay area for Mechanical Engineers to work on electronic countermeasure systems and equipment.

Specialized experience in military design or electromechanical fields is desirable, but not required. More important, applicants should possess initiative, imagination and creative ability.

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ELECTRONIC DEFENSE LABORATORY
SYLVANIA
SYLVANIA ELECTRIC PRODUCTS INC.
Box 205 - Mountain View, Calif.

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$10,000-$12,000. Our client seeks a young progressive promotional E.E. or M.E., for new product design. Position leads to chief design engineer. If you have experience in electrical or electronic equipment you qualify. Client assumes entire cost. Your confidence respected.

MONARCH PERSONNEL
28 E. Jackson Blvd. Chicago 4, Illinois

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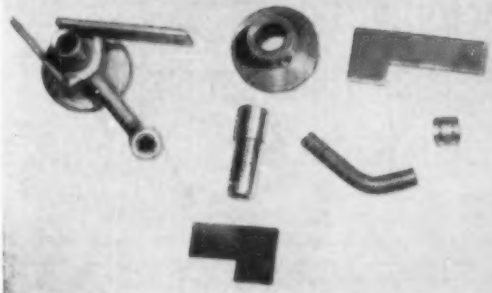
AS PRECISION CAST...

$4.90

AS ORIGINALLY PRODUCED



$?.00

Precision Metalsmiths casts this valve as a pressure-tight unit in a beryllium copper alloy at the unbelievably low cost of $4.90.

Figure what it would cost—at your overhead—to produce, handle and stock the six brass, copper and steel parts that formerly went into this assembly. Then add fabrication costs, with an allowance for leaker-rejects that showed up all too frequently.

We can't promise you savings like this, of course. But the expendable pattern process gives product designers a free rein; your men *imagine* what they'd like to have and we cast it for them. Many machining and assembly operations can be eliminated and, often, parts are made in alloys that can't be machined—a fraction of an ounce up to 10 pounds.

Say "when"

you're worried about high costs

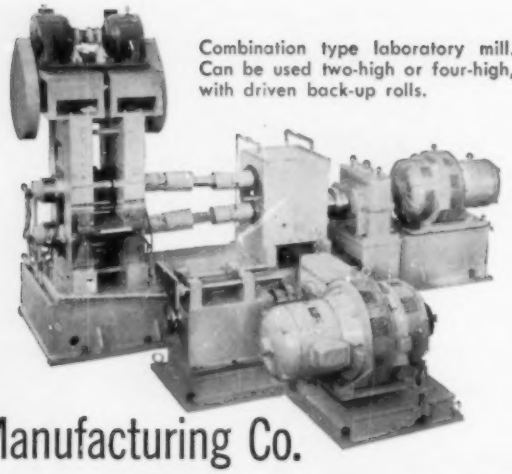
and we'll send you this free book

PRECISION METALSMITHS, INC., 1079 East 200th St., Cleveland 17, Ohio

pour yourself an assembly with

PRECISION METALSMITHS INC.

INVESTMENT CASTINGS



Combination type laboratory mill. Can be used two-high or four-high, with driven back-up rolls.

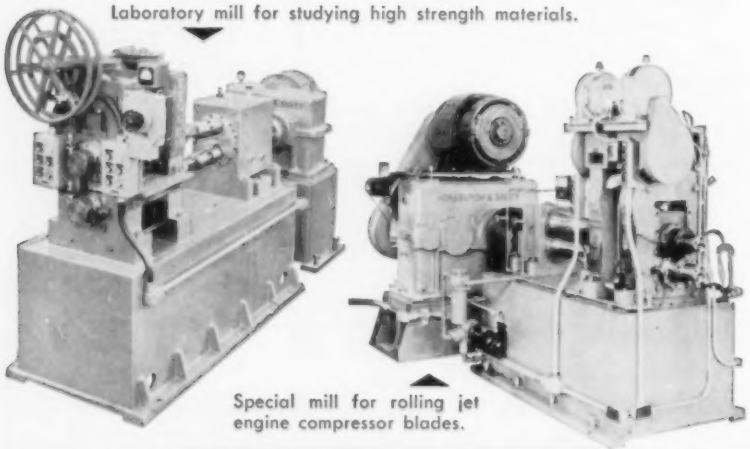
Why
Fenn Manufacturing Co.
equips its precision rolling mills with
H & S Speed Reducers and Gears

Manufacturers of precision metal forming equipment, the Fenn people necessarily must buy carefully when selecting components from other sources. When it comes to speed reducers and worm and gear sets, they rely on *Horsburgh & Scott.*

The Fenn rolling mills illustrated here are built to order for both production and laboratory use. H & S Speed Reducers are in evidence, sized to suit the need. H & S worm and gear sets are used in the screw down mechanisms.

The rugged dependability of H & S products, helpful and flexible engineering service, and reliable delivery performance are principal values in a continuing profitable relationship . . . There's a solution to *your* power transmission problem in the broad lines of gears and assembled units made by H & S. Write us, or contact your nearby H & S representative.

Laboratory mill for studying high strength materials.



Special mill for rolling jet engine compressor blades.

THE HORSBURGH & SCOTT CO.
GEARS AND SPEED REDUCERS
5112 Hamilton Avenue
Cleveland 14, Ohio

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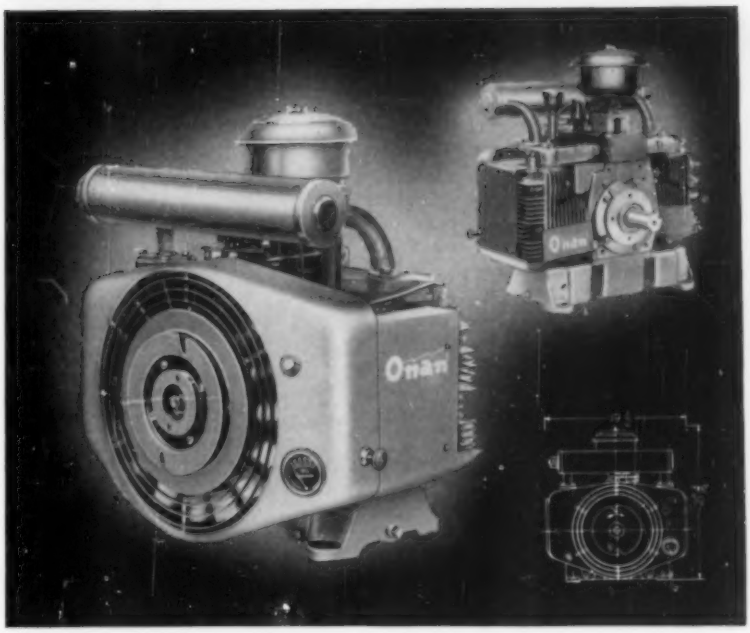
Onan PRODUCTS

AIR COOLED ENGINE NEWS

Onan PRODUCTS



New engine ends vibration problems on power equipment

Alternate-firing, two-cylinder, opposed design Onan CCK runs smoother. Low silhouette and short crankshaft save space.

The Onan 12.9 H.P. CCK engine offers unique advantages for any type of installation. Its smoothness permits mounting in unusual locations since heavy supporting members are not necessary. Because it operates more quietly it can be used where noise must be kept to a minimum.

Its total height of 21 $\frac{1}{16}$" fits designs where the "low, modern look" is a selling feature or where a low center of gravity is desirable. Front to back the CCK measures only 14$\frac{3}{4}$" . . . an advantage where the engine must be mounted close to a vertical surface.

The CCK is specially designed for installations on power equipment where a continuous-duty, durable engine is essential. Long-life features include extra-large bearing surfaces, Stellite valve facings and Stellite seat inserts.

The Onan CCK has helped win sales leadership for many manufacturers.

Onan Model DRP
Air-cooled Diesel

Two-cylinder, opposed. 15 H.P. at 2300 R.P.M. 4-cycle. Solid injection full Diesel. Electric starting.

Onan Model AJ
Single-cylinder

5.5 H.P. Gasoline powered. 4-cycle. A compact, rugged, high-performance engine for heavy-duty use.

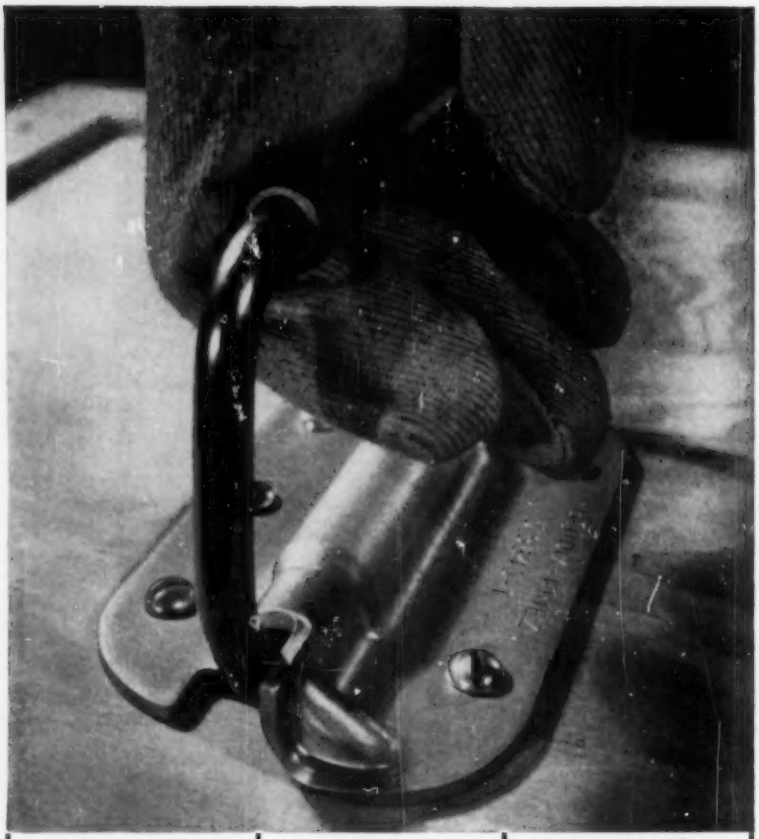
Write for complete specifications or call Minneapolis, FEderal 2-1155

D. W. ONAN & SONS INC.

Onan PRODUCTS

3829 University Ave. S. E., Minneapolis 14, Minnesota

ELECTRIC PLANTS • AIR-COOLED ENGINES • GENERATORS • KAB KOOLER


400 LBS.
SNAPS BACK
Reclaiming spring forces grip down. Holds it firmly in place against surface.
NO PINCHING
Handle back plate design permits grip to lift to 90° position. Keeps fingers free.
EXTRA STURDY
Easily attached, each handle is strong enough to lift 200 lbs. with ample safety factor.

BEST HANDLE YET FOR INDUSTRIAL CONTAINERS, CARRYING CASES OR ELECTRONIC EQUIPMENT!

Meets Military Specifications C-4150A and T-945A

There's nothing fragile about this handle! It's strong, rugged, rattle proof, rust and corrosion resistant. Made of tough stainless steel and heavy-gauge anodized aluminum, it will lift 200 lbs. with a big safety factor in reserve.

This Bendix handle has proven its superiority on military and industrial carrying cases, shipping containers and on electronic equipment. The special grip sleeve will not crack, chip, become sticky or tacky in temperatures from -65° to $+160^{\circ}$F. Our patented design eliminates pinching, holds grip firmly against surface when not in use. Attaches easily with nuts and bolts, welding, etc.

Write today for complete specifications and quantity discounts. Bendix-Friez, 1404 Taylor Ave., Baltimore 4, Maryland.

Friez Instrument Division

Bendix AVIATION CORPORATION

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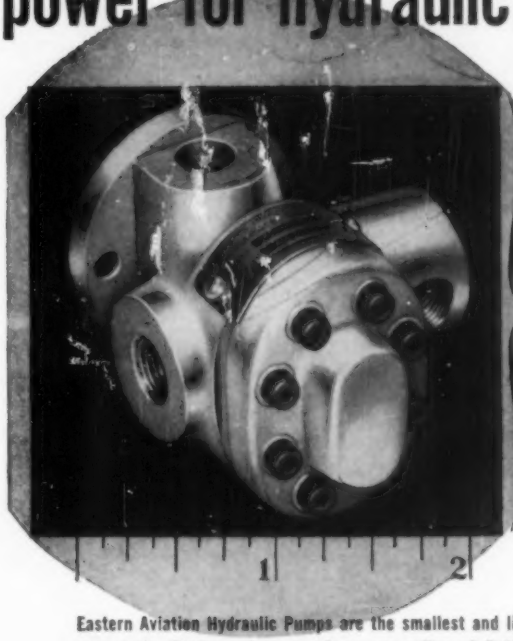
power for hydraulic systems



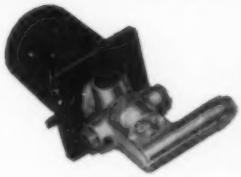
comes in small packages

Eastern Aviation Hydraulic Pumps are the smallest and lightest line of pumps ever made. They supply as much as one gallon of fluid per minute against pressures as high as 2000 PSI.

The 1700 Series of high speed gear pumps have theoretical displacements varying from .0021 to .0251 cubic inches per revolution. This series of pumps can be close-coupled directly to various electric motors. They are made in many configurations with and without integral bypasses. A variety of bearing combinations handle different types of fluids and operating pressures.

Eastern engineers can adapt and design hydraulic pumps to meet your specifications. On your next project, contact Eastern for engineering help that really helps.

Eastern 1700 SERIES PUMPS



1733-HBU-249

1731-LCU-205

1781-HBV-255

1700 SERIES PUMP

See you at Wescon Show —Booth 3216.

Send for Aviation Bulletin 340

Eastern INDUSTRIES, INC.

100 SKIFF ST. • HAMDEN, CONN.

If it's HOT or DRY

USE 'DIAMOND H' SERIES R RELAYS

Where the temperature hits 200°C. or the dry circuit is downright arid, your best bet for reliability is a "Diamond H" Series R miniature, hermetically sealed, aircraft type relay. Their shock and vibration resistance you may take for granted.

On the other hand, Series R relays (4 PDT) also give excellent reliability at —65°C. and will carry up to 10 amperes in power circuits . . . or even 20 amperes for short life requirements. In other words, they offer an extremely wide range of performance characteristics from which "Diamond H" engineers will be happy to work out a variation to meet your specific requirements. Just ask.

TYPICAL PERFORMANCE CHARACTERISTICS

Vibration Resistance:	10-55 cycles at 1/16" double amplitude 55-500 cycles at 15 "G" 55-1,000 cycles at 15 "G" 55-2,000 cycles at 20 "G"
Temperature Range:	—55° to +85°C. —65° to +125°C. —65° to +200°C.
Coils:	Resistances—1 ohm to 50,000 ohms Arrangements—single coil; two independent coils, either or both of which will operate unit
Insulation Resistance:	1,000 megohms at room temperature 100 megohms at 200°C.
Dielectric Strength:	450 to 1,000 V., RMS
Operating Time:	24 V. models 10 ms. or less; dropout less than 3 ms.
Contacts:	30 V., D.C.; 115 V., A.C.; 2, 5, 7½ and 10 A., resistive; 2 and 5 A. inductive Minimum 100,000 cycles life. Low interelectrode capacitance—less than 5 mmf. contacts to case; less than 2½ mmf. between contacts. Special Ratings: to 350 V., D.C., 400 MA., or other combinations including very low voltages and amperages or amperages to 20.
Operational Shock Resistance:	30, 40 and 50 "G" plus
Mechanical Shock Resistance:	up to 1,000 "G"
Mounting:	9 standard arrangements to meet all needs —plus ceramic plug-in socket.
Size:	1.6 cu. in.
Weight:	4 oz. or less

Bulletin R-250 gives more complete data. Send for a copy.

THE HART MANUFACTURING COMPANY

206 BARTHOLOMEW AVENUE, HARTFORD, CONN.

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FELLOW VISIONARIANS: K&E Albanene® Tracing Paper keeps your originals clear for life . . . substantially lowers your operating costs.

K&E Albanene has more desirable working qualities than any other tracing paper. Its superiority begins with the stock—100% rag paper with the longest fiber in the business, made only for K&E. This gives Albanene its extraordinary tear strength with the greatest possible transparency. Original drawings stand up year after year under repeated reproductions without damage or loss of clarity.

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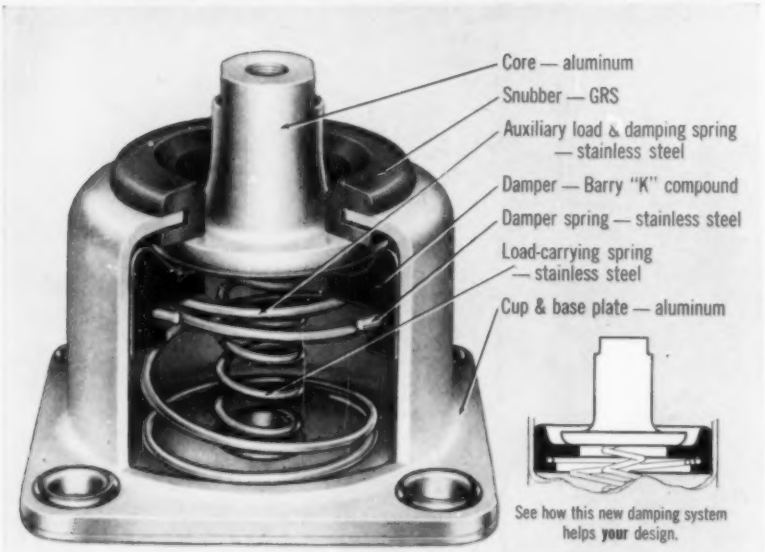
Barry's New "Lo" Mount meets MIL-C-172B at low cost

— with this extra vibration isolation that adds reliability to your design.


Core — aluminum
Snubber — GRS
Auxiliary load & damping spring — stainless steel
Damper — Barry "K" compound
Damper spring — stainless steel
Load-carrying spring — stainless steel
Cup & base plate — aluminum
See how this new damping system helps **your** design.

MIL-size 1 "LO" Mount shown 1½ times actual size

We designed for lower cost — *and developed a better mount for MIL-C-172B.* Even at 10° inclination, this new mount performs effectively. And its characteristics far exceed requirements of MIL-C-172B.

The simple and versatile design of the "Lo" mount lets us match characteristics to your specification. Your design now gains added reliability with a mount that more than satisfies MIL-C-172B — and at low cost.

Extra-low transmissibility and low natural frequency

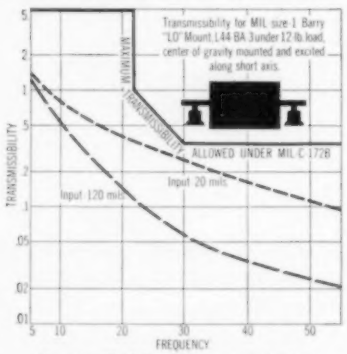
Transmissibility below 2 at resonance in all load ranges is a major advantage of the "Lo" mount. This isolator handles high-amplitude inputs without snubbing, even at resonance and at 10° tilt.

Very low rocking modes

In base-mounted systems, transmissibility of rocking modes under horizontal vibration is so reduced that they are indiscernible. This is due to the inherently low ratio of horizontal-to-vertical stiffness plus *self-centering* horizontal friction damping.

For center-of-gravity designs

Independent horizontal damping makes the "Lo" mount especially suited for installation in the plane of center-of-gravity of the equipment.


Transmissibility for MIL size 1 Barry "LO" Mount L44-BA 3 under 12 lb load, center of gravity mounted and excited along short axis.
RESONANCE
TRANSMISSIBILITY
ALLOWED UNDER MIL-C-172B
Input 20 mils
Input 120 mils
TRANSMISSIBILITY
FREQUENCY

Controllable characteristics

These exceptional characteristics, resulting from the unique Barry spring and friction-damping design, can be controlled in manufacture for high performance with a wide variety of equipment. Special versions of the "Lo" mount will control transmissibility at resonance for a given input or handle very high-amplitude inputs at resonance without snubbing.

Physical characteristics

The L44 Mount is available in 7 load ranges from 0.25 to 10 lbs. per mount in long- and short-core models. It meets environmental and vibration requirements of Procedure I, MIL-E-5272A. Temperature range is −85 to +250F. Weight is 1½ oz. each.

Write today for Data Sheet 57-05.

BARRY B MOUNT

BARRY CONTROLS
INCORPORATED
SALES REPRESENTATIVES IN ALL PRINCIPAL CITIES

730 PLEASANT STREET, WATERTOWN 72, MASSACHUSETTS

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Darcova Pumcup

put Pumcups in your cylinders

TO HOLD PRESSURE LONGER!

In Darcova Pumcups a sound engineering principle has been combined with precision tolerances and extremely durable compositions to provide exceptional efficiency and life in hydraulic, air, and reciprocating pump cylinders of all kinds.

Unlike ordinary piston packing, precision Pumcups are engineered to minimize friction load while hugging cylinder walls on every pressure stroke. Regardless of eventual wear, efficiency *stays* high! So there's far less down-time and need for replacement.

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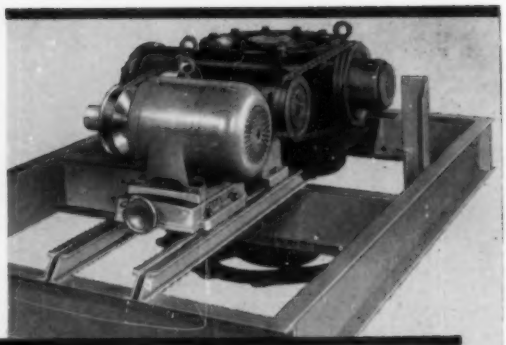

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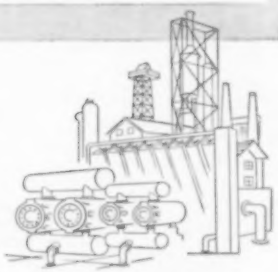

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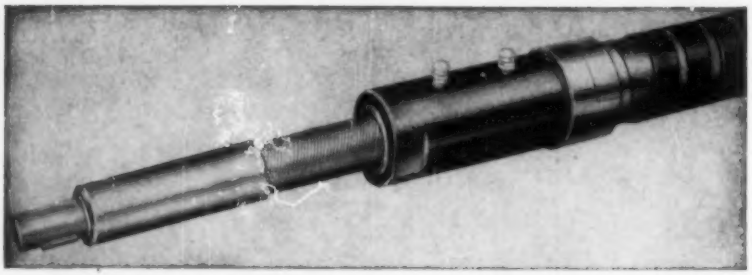
HOW TO SELECT
FLEXIBLE SHAFTING FOR POWER DRIVE APPLICATIONS



1¼-inch STOW Power Drive flexible shaft with core assembly pulled out of casing.

For Power Drive applications, the following factors must be considered:

1. Torque (Lb. In.) to be transmitted. (The starting torque should be used in making selections.)

2. Operating Speeds (RPM)—If the maximum speed is higher than the rated speed, torque ratings in the table below do not apply. To find the torque capacity for flexible shafts operating at speeds higher than the rated speeds, multiply the maximum dynamic torque capacity by the rated speed, and then divide by the operating speed. (See example.)

3. Operating Radius—In making the selection from the table below, the radius of the smallest bend in the flexible shaft should be used.

RATINGS—The ratings for flexible shafts shown in the table below apply under the following conditions:

1. when the flexible shaft is adequately supported by clamps along its length. (For unsupported shafts, multiply the calculated torque by a safety factor of 1.6—see example below.)

2. when the flexible shaft is operated in the wind-up direction, which tends to tighten the outer layer of wires. (Flexible shafts operated in the unwind direction will transmit only about 60% of the rated torque.

3. when the flexible shaft is in continuous operation. Note: **the ratings are based on temperature rise. When the operation is intermittent, the ratings in the table may be exceeded. Consult Stow engineers for specific recommendations.**

RATED SPEED R.P.M.	MAXIMUM DYNAMIC TORQUE CAPACITY (LB. IN.) STRAIGHT AND CURVED SHAFTS RADIUS OF CURVATURE IN INCHES									Wgt./ C. Ft.	Core Dia.	Core No. and Type	Shaft Size
	50 to Strgt.	25	20	18	12	10	8	6	5				
4,500	2.4	2.2	2.0	2.0	1.92	1.9	1.7	1.5	1.25	3.0	.124/.128	2049 MH	13
3,800	7.0	6.4	6.0	5.8	5.4	5.0	4.6	3.6	2.0	4.5	.148/.152	2081 MH	15
2,900	9.4	8.8	8.0	7.6	7.0	6.6	6.0	4.8	3.4	7.0	.185/.189	5108 MH	19
2,500	22.0	20.0	18.8	17.6	16.0	15.0	12.6	10.8	9.0	12.5	.247/.252	8924 MH	25
1,800	30.0	28.0	26.4	25.0	23.0	21.0	18.0	14.0		20.0	.308/.313	8925 MH	31
1,800	33.8	31.5	29.7	28.1	25.9	23.6	20.2	15.8		20.0	.308/.313	8969 T	31
1,800	36.0	33.0	31.6	30.0	28.0	26.0	22.0	18.0	11.0	21.0	.324/.329	2034 A	31
1,500	80.0	66.0	63.0	58.0	51.0	46.0	37.0	22.0		28.5	.368/.374	2035 A	38
1,500	60.0	54.0	50.0	46.0	42.0	38.0	30.0	24.0		29.0	.387/.393	8970 MH	40
1,500	90.0	81.0	75.0	69.0	63.0	57.0	45.0	36.0		29.0	.387/.393	8971 T	40
1,150	136.0	110.0	104.0	94.0	80.0	72.0	56.0			50.5	.497/.503	8999 A	50
1,150	148	124	110	92	72	56				53.5	.505/.511	6940 T	50
900	248	200	176	124	84					78.5	.610/.618	6997 T	63
900	220	204	192	180	152	130				80.5	.630/.638	7731 A	63
750	340	224	156	76						117	.747/.753	2056 T	75
600	760	520	420							205	.998/1.004	2057 T	100
440	1,500	720								343	1.298/1.304	2058 T	125

EXAMPLE—How to use the table:
The problem is to transmit ½ HP at 1700 RPM through an unsupported flexible shaft in a 25" radius, estimated starting torque 150% of normal operating torque.

1. Calc. Torque (lb. in.)—
$$\frac{HP \times 63000}{RPM} = \frac{.5 \times 63000}{1700} = 18.5$$
2. Correction factor for starting torque 1.5 x 18.5 = 27.75
3. Correction factor for unsupported shaft 27.75 x 1.6=44.4 lb. in.
4. Refer to Table No. 1. Read downward in column under 25" radius until you find a core having a rating of at least 44.4 lb. in. In this case we find that core No. 8970 is rated 51 lb. in. at 1500 RPM. Since the given speed is 1700 RPM, multiply 51 by 1500 and divided by 1700. 51 × 1500 ÷ 1700 = 42.6 lb. in. (rated torque at 1700 RPM). Therefore, Core No. 8970 is correct.

For Engineering Bulletin No. 570 and a free torque calculator, write

STOW MANUFACTURING COMPANY
426 State Street, Binghamton, New York

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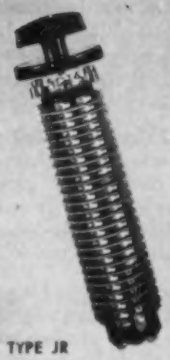
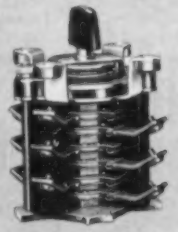
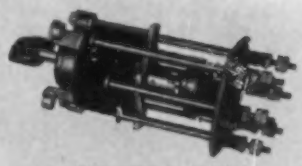


TYPE JR

TYPE A



TYPE P, 30A



TANDEM TYPE P, 30-10A

TYPE HT

- Save valuable panel space
- Simplify control of complex circuits
- Give "dead-front" mounting safety
- Listed by Underwriters Labs, Inc.
- Can be furnished to latest Navy specs.
- Ratings from 2 amperes to 200 amperes, 30 to 250 volts d. c., and 125 to 500 volts a. c. — depending on number of circuits and nature of load.

Write for combined catalog giving useful design data on Esco rotary switches.

ELECTRO SWITCH
CORPORATION
167 King Avenue, Weymouth 88, Mass.

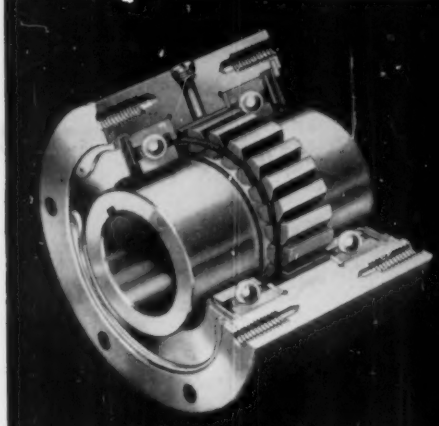
Roomful of restless men

You're looking at a roomful of design engineers. Like yourself, perhaps, they push themselves to achieve a "let's do it better for our customers" result. It's idea-creating work in a challenging mental atmosphere.

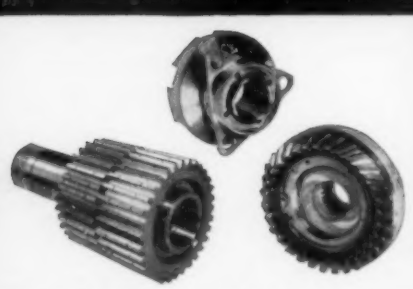
They work mostly on special clutch applications . . . been doing it for years. When a job poses a new problem they ask themselves: "Can we use one of our standard designs in this assembly rather than create a new one?" . . . More often than not their answer can be yes.

Secret of this adaptability is the result of pioneering engineering experience combined with Formsprag's basically simple design (see cutaway photo below). Imagine how these skilled designers can modify components to cover an enormous range of applications. The cost is usually only slightly above that of a standard model.

Drawing on their long experience with special application problems, Formsprag engineers are able to custom-tailor clutches from production line parts. You can rest—and plan—assured that Formsprag will design, build prototypes and volume produce special clutches to your complete satisfaction.



Standard Ball Bearing All-Purpose Formsprag Clutch. Note its simplicity of design. Between inner and outer races a full complement of sprags is inserted. Energizing springs hold sprags in contact. Formsprag construction allows more sprags to be inserted in a smaller area than other clutch designs. Result: greater torque capacity in a smaller clutch.



Special application Formsprag clutches like these can be priced advantageously when the application calls for use of Formsprag's vast fund of developmental engineering know-how. Let us send you literature that discusses in detail Formsprag clutches for standard and special applications.

Over-Running, Indexing and Backstopping Clutches for aircraft, automotive, and various industrial applications.

FORMSPRAG COMPANY

(A6-11B)

23607 HOOVER ROAD, VAN DYKE, MICHIGAN

World's Largest Exclusive Manufacturer of Over-Running Clutches

Distributors in principal cities

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Now, one of these handy prepaid postcards will bring you more information about any product advertised or mentioned editorially in this issue of *Product Engineering*.

Here's How to Use the Card

For your copy of any new catalog or bulletin, circle key numbers in the space indicated. Bulletins are described on pages 288-312.

To get more data about new Components, Materials and Parts fully described on pages 220-284, just circle the appropriate key number.

To get more information about advertised products, circle the page number of the advertisement in which you are interested. If more than one advertisement is located on a single page, letters preceding number identify each advertisement. Key: T—Top; B—Bottom; R—Right; L—Left; TL—Top left; BL—Bottom left; TR—Top right; BR—Bottom right.

For specialized data . . . prices, sizes available, nearest source of supply, etc. . . . do not circle key number but indicate your needs in the space allotted at the bottom of the card. Use this space, too, if information about a specific product among several mentioned in an advertisement is desired.

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NEW PRODUCTS . . . Description of these new engineering materials appear on pages 220-284. Circle key number for more data

1—Motor Starters Are 42% Smaller
2—Directional Control Valves
3—Filters Have Simplified Drain Mechanisms
4—Spiral Plastic Wrapping
5—Electro-Mechanical Counter
6—Subminiature Indicator Tube
7—Photoelectric Shaft Position Encoder
8—Hydraulic Gear-type Pump
9—Automatic Control of Test Limits
10—Magnetic Clutch
11—Miniature Hydraulic Cylinders
12—Integrates or Averages Shaft Position, Displacement
13—Miniature Magnetic Clutch
14—Shunt-Relay Style Circuit Breakers
15—Lead Screw Revolution Counter
16—Transistor Clip Dissipages Heat
17—Power Take-off Throttle Control
18—Submersible Motors
19—Reinforced Conductor
20—Automatic Voltage Regulator
21—Thyratron Tube With 1 Amp Rating
22—Transistor-Equipped Converter
23—Transistor-Equipped Voltmeter
24—High-Temperature Connectors
25—Printed Circuit Connectors
26—Controller Has Long Life
27—Single Coil Induction Motor
28—Voltage Regulator
29—Wiring Strain Relief Clip
30—High Temperature Switch
31—Self-Lubricating Shaded Pole Motor
32—High Frequency Transformers
33—D-C Amplifier
34—Rotary Solenoid
35—Magnetic Amplifier Regulator
36—Miniature Switches
37—Electromagnetic ¼ hp Motor Starter
38—Vernier Potentiometer
39—Polyester Web Tapes
40—Electric Brake for Standard NEMA C Motors
41—Pushbutton Selector Switches
42—Sub-miniature Pilot Light
43—Check Valve for Pumps
44—Combination Gas Valve
45—PVC Lift Check Valve
46—Air Filter For Pneumatic Equipment
47—Motor-Operated Globe Valve
48—Vacuum Ball Valves
49—Electro-Hydraulic Valves
50—Ceramic Bonds to Stainless Steels
51—Heat-Resistant Phenolic Compounds

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CIRCLE THESE NUMBERS FOR FURTHER INFORMATION ON PRODUCTS ADVERTISED

C2	1	2	4	L6	R6	8	11	13	14	15	16	17	18-9
20-1	22-3	24-5	26-7	28-9	30	31	32	33-4	35	36	37	38-9	40
41	42	43	44	45	46	47	48	49	50-1	52	53	54	55
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272	273	274	275	L276	R276	276A-D	277	278	279	280	281	282	283	284
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L349	R349	L350	TR350	BR350	TR351	BR351	T352	BL352	BR352	353	L354	TR354	BR354
L355	R355	L356	TR356	BR356	357	TL358	BL358	BR358	359	TL360	BL360	TL361	BL361
R361	363	364	365	366	367	368	369	370	371	372	373	374	375
376	C3	C4											

CIRCLE THESE NUMBERS FOR INFORMATION ON NEW PRODUCTS LISTED IN THIS ISSUE

1	2	3	4	5	6	7	8	9	10	11	12	13	14
15	16	17	18	19	20	21	22	23	24	25	26	27	28
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43	44	45	46	47	48	49	50	51	52	53	54	55	56
57	58	59	60	61	62	63	64	65	66	67			

CIRCLE THESE NUMBERS FOR COPIES OF NEW BULLETINS IN THIS ISSUE

68	69	70	71	72	73	74	75	76	77	78	79	80	81
82	83	84	85	86	87	88	89	90	91	92	93	94	95
96	97	98	99	100	101	102	103	104	105	106	107	108	109
110	111	112	113	114	115	116	117	118	119	120	121	122	123
124													

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52—High-Temperature Plastic
53—Teflon Tubing
54—Leveling Device
55—High-Strength Shoulder Screws
56—Chevron Seals for −350 F to 500 F
57—Clutches for Heavy Duty
58—Fine Pitch Gear Racks
59—Hex-Head Self-Locking Screws
60—Black Nylong Cap Nuts
61—Heavy Duty Caster
62—Screw Head Hose Clamps
63—Wide Range Milling Spindle
64—Speed Measurements
65—Makes Large Photocopies
66—Flareless Tube Fitting Templates
67—Universal-Type Bow Instrument

NEW BULLETINS . . . listed below are described

on pages 288-312. Circle key number for your copy.

68—Magslips, 60 pp, Muirhead Instruments, Inc.

69—Nickel-Base Alloys, 104 pp, Haynes Stellite Co., Div. Union Carbide Corp.

70—Sprayed-on Heating Element, 8 pp, Thermflex Div., Verrall Moe Electronics, Inc.

71—Fasteners, 40 pp, Ohio Nut & Bolt Co.

72—Mica Properties, 6 pp, Ford Radio & Mica Corp.

73—Brass Tube Fittings, 48 pp, Weatherhead Co.

74—Standard Mold Bases, 170 pp, Detroit Mold Engineering Co.

75—Variable Transformers, 28 pp, Superior Electric Co.

76—Oil Seals, 68 pp, Chicago Rawhide Mfg. Co.

77—Leaded Alloy Steel, 4 pp, Horace T. Potts Co.

78—Diaphragm Operated Valves, 4 pp, Seely Instrument Co., Inc.

79—Breadboard Parts, 24 pp, Helipot Technical Information Service

80—Electrical Insulation, 12 pp, Insulation Manufacturers Corp.

81—Relays, 16 pp, Magnetcraft Electric Co.

82—Self-Locking Pins, 6 pp, Aviation Developments, Inc.

83—Valves, 4 pp, Milton Roy Co.

84—Pumps and Valves, 12 pp, Hills-McCanna Co.

85—Plastic Reinforcement, 8 pp, L.O.F. Glass Fibers Co.

86—Investment Cast Vacuum Alloys, 7 pp, Cannon-Muskegon Corp.

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PRODUCTS ADVERTISED

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L349	R349	L350	TR350	BR350	TR351	BR351	T352	BL352	BR352	353	L354	TR354	BR354
L355	R355	L356	TR356	BR356	357	TL358	BL358	BR358	359	TL360	BL360	TL361	BL361
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376	C3	C4											

NEW PRODUCTS . . .

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110	111	112	113	114	115	116	117	118	119	120	121	122	123
124													

SPECIFIC DATA . . .

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87—Piezoelectric Pressure Transducers, 2 pp, Atlantic Research Corp.

88—Cabinets, 26 pp, Metal Products Div., Mid-West Conveyor Co.

89—Printed Circuits, 6 pp, Westinghouse Electric Corp.

90—Cycling Drive Unit, 12 pp, Cycledynamics, Inc.

91—Variable Speed Drives, 8 pp, Worthington Corp.

92—Steel Tubing and Pipe, Data Chart, Peter A. Frasse & Co., Inc.

93—Chains, Sprockets, Buckets, 24 pp, Chain Belt Co.

94—Variable Speed Drives, 8 pp, Dayton Rubber Co.

95—Electrical Connectors, 8 pp, Burndy Corp.

96—Air Conditioner Thermostat, 4 pp, Robertshaw-Fulton Controls Co.

97—Motor Generator, 2 pp, Helipot Technical Information Service

98—Extrusion Data, 12 pp, Precision Extrusions, Inc.

99—C Cores, 24 pp, Westinghouse Electric Corp.

100—Motors, Drives, 8 pp, Reliance Electric and Engineering Co.

101—Relief and Back-Pressure Valve, 1 p, Atlas Valve Co.

102—Proving Rings, 12 pp, Morehouse Machine Co.

103—Valves, Driers, Strainers, 16 pp, Henry Valve Co.

104—High-Temperature Alloys, 4 pp, Westinghouse Electric Corp.

105—Conversion Tables, 6 pp, Barnes Engineering Co.

106—Variable Voltage Adjustors, 4 pp, Acme Electric Corp.

107—Bimetal Thermostats, 4 pp, Stevens Mfg. Co., Inc.

108—Volume Pumps, 32 pp, Milton Roy Co.

109—Multi-Contact Relay, 4 pp, Phillips Control Corp.

110—Truck Bumpers, 2 pp, Bumpers, Inc.

111—Wireway, 4 pp, General Electric Co.

112—Motors, 4 pp, Marathon Electric Mfg. Corp.

113—Heating Problems, folder, Electrofilm, Inc.

114—Wire, Cables, 40 pp, Phalo Plastics Corp.

115—Wrappings, list, Cincinnati Industries, Inc.

116—Automatic Tools, 4 pp, Dixon Automatic Tool, Inc.

117—Electrical Equipment, 20 pp, Sittler Corp.

118—Mercury-Plunger Relay, 8 pp, Ebert Electronics Corp.

119—Columbium and Tantalum, 4 pp, Shieldalloy Corp.

120—Voltage Regulators, 8 pp, Victoreen Instrument Co.

121—Pulse Calibrator, 4 pp, Burroughs Corp.

122—Panel-Mounting Instruments, 36 pp, Trio Laboratories, Inc.

123—Screen Resist, 6 pp, Techniques Sales Co.

124—Tube Fitting, Wall Chart, Tube & Hose Fittings Div., Parker Appliance Co.

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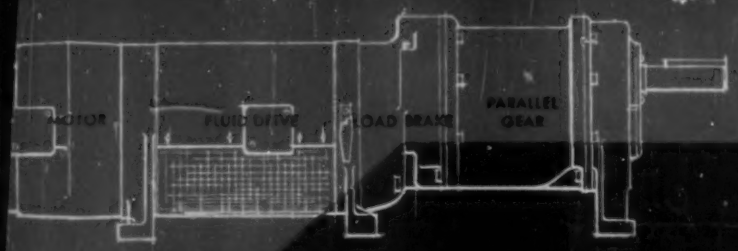

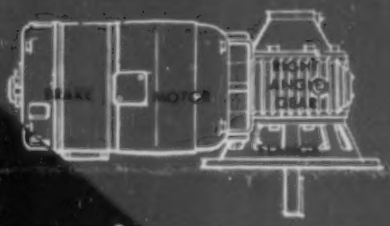

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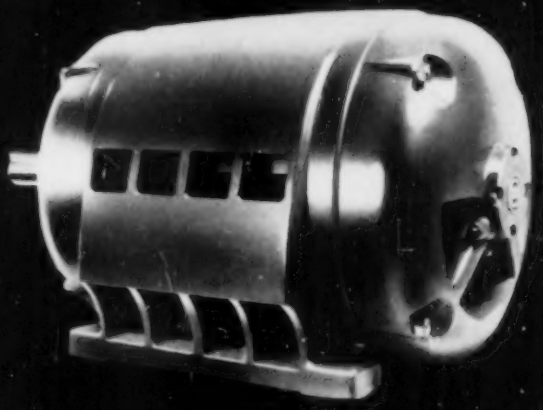
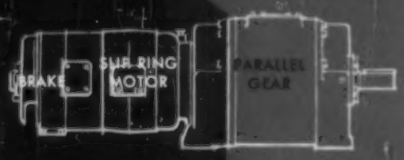
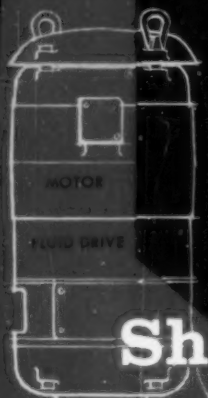
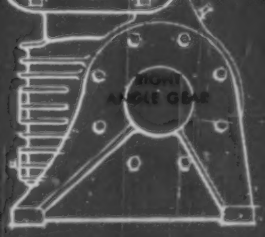
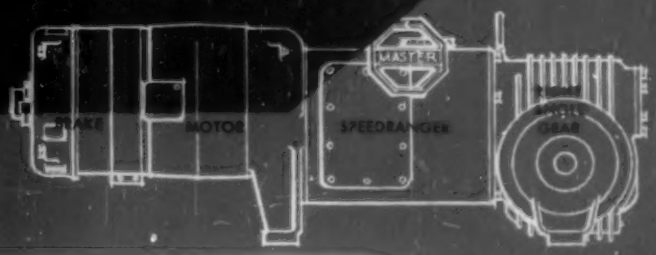








Should meet their Master



Master Units Combine into Engineered, Customized Package Drives—Providing the Right Shaft Speed, the Right Construction Features, the Right Mounting. Why Put Up With Makeshift Assemblies?

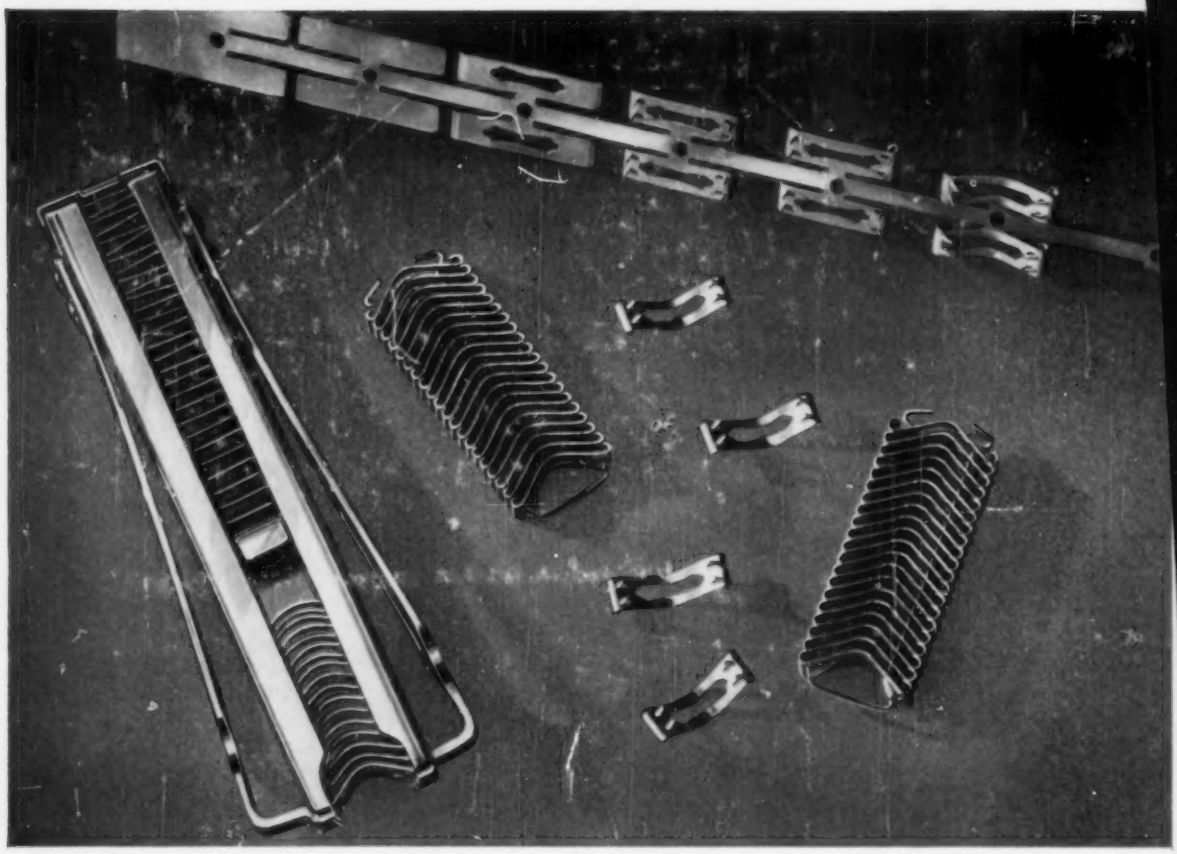
Engineers and Manufacturers of

Electric Motors	**⅛ to 400 H.P.**
Gearmotors	**⅛ to 125 H.P.**
Variable Speed Drives	**⅛ to 30 H.P.**
Unibrake Motors	**⅛ to 150 H.P.**
Fluid Drive Motors	**½ to 15 H.P.**

Alternating current motors, direct current motors, generators . . . open, enclosed, explosion proof . . . with 5 types of gear reducers . . . with electric brakes . . . with mechanical or electronic variable speed units . . . with fluid drives . . . Master has them all and so can be completely impartial in helping to select the one best drive for you.

MASTER ELECTRIC MOTORS

THE MASTER ELECTRIC COMPANY, Dayton 1, Ohio



Above: The various steps in forming Autoclips® from Anaconda 18% Nickel Silver strip, .637" wide by .013" thick. Below are individual Autoclips and those mounted in wire holders ready for insertion in Autoclip Applier, at left. Exclusive wholesale distributor for Autoclip is Clay-Adams, Inc., New York City. ***Below, left:*** Autoclips being used to attach skin towel to edges of incision.

Anaconda Technical Service helped in

Selecting the exact Nickel Silver strip for this surgical clip

THE PROBLEM: The Technical Oil Tool Corporation, Los Angeles, developed Autoclip, an automatic magazine-type clip and applier to close wounds or incisions faster and easier. Selecting the right metal for the clip was the problem. A certain amount of tension was required to hold the wound edges together during healing, with the least amount of damage to tissues. In addition, the clip had to open easily for painless removal. The metal should be easy to form, and retain sharp, die-cut edges.

THE SOLUTION: After several unsuccessful attempts with various metals, sample clips of the required gage were made of Nickel Silver. These silvery white copper-alloys have excellent resistance to corrosion in service or in storage and have been time-tested for surgical instruments and equipment. Technical specialists of The American Brass Company suggested Nickel Silver, 18%-719—one of four standard Anaconda Nickel Silver Alloys—as the one best suited to meet all the requirements including tension, formability, clean edges and sharp points.

FREE TECHNICAL SERVICE: Metallurgists and technical specialists in The American Brass Company, through their day-to-day work with a great variety of metal problems, offer a tremendous breadth of experience. And this experience is at your disposal—to help you select the exact alloy, form, temper for your job. Call your American Brass Company representative, or write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

ANACONDA®

COPPER, BRASS, BRONZE *and* NICKEL SILVER

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